A RAND NOTE

Mortar Utilization at the Army's Combat Training Centers

Stephen J. Kirin, Martin Goldsmith

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Prepared for the
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PREFACE

This study was carried out as a topic in the continuing National Training Center (NTC) research at RAND's Arroyo Center. The project is sponsored by the Deputy Commanding General for Training (DCG-T) of the Combined Arms Command at Fort Leavenworth. Prior studies have dealt with fratricide, reconnaissance, artillery targeting accuracy, and tube-launched, optically-tracked, wire-guided antiarmor weapon system (TOW) utilization. The present study was requested by the Director of the Center for Army Lessons Learned (CALL), a subordinate agency to the DCG-T.

The request from CALL stated that results from all three Combat Training Centers (CTC)—the NTC, the Joint Readiness Training Center (JRTC), and the Combat Maneuver Training Center (CMTC)—indicated that the mortar weapons organic to maneuver units were underutilized or ineffective in contributing to battle outcomes. The objective of our study was to determine the validity of this indication, and if confirmed, to identify problems and potential solutions. The research plan included the use of data from all three CTCs, as well as doctrinal information and a literature review. We found that mortar utilization could be improved and indicate remedial measures. This Note should be useful to doctrine writers, trainers, and field soldiers.

THE ARMY FELLOWS PROGRAM

Lieutenant Colonel Stephen Kirin is an Army Research Fellow at RAND. The U.S. Army established the RAND Army Fellows program in 1985. The purpose of the program is to allow Army officers to broaden their perspective of Army policy and technology issues by exposure to diverse attitudes and perspectives embodied in the RAND work force. Furthermore, the program supports Army Fellows in learning advanced analytical techniques to study policy and acquisition issues.

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Lynn E. Davis is Vice President for the Army Research Division and Director of the Arroyo Center. Those interested in further information concerning the Arroyo Center should contact her office directly:

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SUMMARY

BACKGROUND

This study was initiated at the request of Center for Army Lessons Learned (CALL), whose data collection process at the Combat Training Centers (CTCs) indicated to them that the mortar platoons and sections in both light and heavy battalions, in the United States and in Europe, were not making an effective contribution to battle outcomes. Whereas their data contained anecdotal points and summary statements of mortar unit problems, CALL wished for a more systematic investigation of the mortar problem so it could recommend remedial actions.

The objectives of our work were to answer four questions. First, is it true that mortars are underutilized at the CTCs? Second, are CTC results a proper measure of mortar performance? Third, if the answers to the first two questions are affirmative, can the causes of underutilization be identified? Fourth, can fixes be identified in doctrine, training, organization, leadership, or equipment to improve mortar performance?

PRELIMINARY ANALYSIS

The first step in our work was to review Take Home Packages (THP) prepared by the Operations Groups at the CTCs to assist units in evaluating their training experience. The data in the THPs indicated that the number of mortar missions fired in a battle was low; however, no absolute standards exist. Data also showed that the number of mortar rounds expended was substantially below the unit basic load and below staff planning recommendations. Mission effectiveness was likewise below that usually considered desirable, or even acceptable. Thus there was a good basis for the CALL concerns. However, the existing data yielded only vague clues as to the root cause of these deficiencies.

Arguments were made that the terrain and scenarios did not emphasize dismounted infantry operations at the National Training Center (NTC), and it is generally accepted that the most appropriate application for mortars is against infantry. This might account for low mortar utilization at that CTC. At the Combat Maneuver Training Center (CMTC), the European heavy unit training center, the terrain is more favorable to infantry operation, thus better mortar utilization might be expected there than at the NTC. However, the THP data did not support that theory. These arguments clearly would not hold for Joint Readiness Training Center (JRTC), an infantry training center, yet utilization was considered to be below par there also. Therefore a more thorough study was carried out.

CTC BATTLE SIMULATION

One reason commonly advanced for the apparent ineffectiveness of indirect fires at the CTCs is the nature of the CTC simulation itself. For this reason we carefully reviewed the methods employed at each CTC to replicate indirect fire and its effects. Although the firings cannot be simulated by lasers as are direct fires, the calls for fire are introduced into a fire marker system at all the CTCs. At the NTC, the computer instrumentation system records and displays the fires. At the other CTCs, manual methods are used. At all CTCs, fire markers are dispatched to the impact location of proposed fire calls and upon simulated execution of the mission, the markers discharge marking pyrotechnics. Battle Damage Assessment (BDA) is performed by the fire markers or by observer/controllers (O/Cs) according to fire effects tables. We found that the effects tables and the area affected by the simulated fires varied between CTCs. Clearly these discrepancies should be corrected, and actions are under way in the Army to do so. However, the tables and areas used in the past have probably overstated the lethal effects of mortar fires. Conversely, the CTC simulation systems do not properly account for the suppressive effects of mortar fire. Despite this limitation, we could find nothing in the physical arrangements of the CTC simulation systems that would account for the apparent lack of utilization of mortar capability.

MORTAR ORGANIZATION AND DOCTRINE

Our study covers three types of mortar, light (60mm), medium (81mm), and heavy (107mm), as found in several types of organization. The six-tube heavy mortar platoon is found in heavy battalions, the four-tube medium mortar platoon in nonmechanized infantry battalions, and the two-tube light mortar sections in nonmechanized infantry companies. Appendix A discusses the structure and equipment of the various mortar units. The organization, manning, equipment, and means of fire control are reviewed, with particular reference to how these factors can influence tactical effectiveness. The operating environment of a mortar platoon is contrasted to a field artillery platoon, and it is shown that the mortar leaders face a greater variety of tactical problems.

Section 3 of the Note reviews mortar doctrine. There are two fundamental types of doctrinal instruction. The first concerns the operation of the mortars themselves and includes the technical aspects of gunnery. Our preliminary data review did not suggest, however, that mortar technical operations were a prime source of weapon inutility although we do identify technical issues that reduce the effectiveness of mortars. The second type of doctrine addresses tactical employment. Here one must look at what the mortar unit is instructed to do, and what the parent maneuver unit is instructed to do vis-á-vis mortars.

Doctrine for the Field Artillery, the branch responsible for fire support integration for maneuver units, is an intermediate link between doctrine for mortars proper and maneuver. Thus three sets of doctrine were reviewed, for both heavy and light battalions and their mortars. Although doctrine is complete and unambiguous in most instances, several trouble spots were uncovered, including guidance for when adjustment of fire must be practiced, and guidance for the level of fire required to service various targets. Instruction for means of integrating mortars into the fire plan seemed vague, as were instructions for rehearsal. The doctrinal utilization of mortars in combat was covered, although the depth of coverage varied from manual to manual. Our field investigations, as will be seen, revealed that units frequently failed to follow doctrinal guidance.

DATA SOURCES

Several data sources were used in the conduct of the analysis. Already mentioned were the written Take Home Packages prepared by the CTC staffs. Another source was the archive of operations orders from the NTC maintained at the Army Research Institute (ARI) Field Unit at Monterey, California. These sources are general and do not necessarily probe deeply into the specifics of the various battlefield operating systems. To supplement those data, we devised a series of data cards to be filled out by the O/Cs at the three CTCs after each battle. The cards were tailored to the type of mortar unit and included questions directed at the planning, preparation, and execution phases of the battle. Most questions could be answered with a yes or no, or a number. In this way, the observations of the O/Cs could be collected in a uniform fashion, suitable for analysis. Data for all three classes of mortar were collected at the NTC, with unit battle samples varying from 22 to 64. Only heavy mortars are represented at the CMTC, in 42 battles. At JRTC, medium and light mortars were represented with 11 and 28 unit battles, respectively. The raw data are in tables in App. B.

DATA ANALYSIS AND VERIFICATION OF HYPOTHESES

The questions asked in the data cards were intended to illuminate a variety of hypotheses that had been advanced in the military literature to explain why mortars appeared to be ineffective at the CTCs. The data analysis followed the outline of the hypotheses. The first point to be established was the contribution of the mortars to battle outcome. Data showed that mortars caused little battle damage, and that in fact mortar ammunition expenditure fell far below that expected and provided for in ammunition stockage, thus confirming the preliminary data from the THPs.

One hypothesis for the low utilization was that communications to the mortars were a problem; the data refuted this, as communication was seldom reported as a problem. Another factor put forth as explanation for low mortar effectiveness was that the CTCs do not realistically assess mortar effects. As previously mentioned, the investigation showed that lethal effects may be overstated, but that suppressive effects, which are very important, are not adequately accounted for. A lack of perceived effectiveness may lead to underutilization of the resource.

Some sources claim that doctrine does not clearly establish staff responsibilities for mortars. We found that this is not a valid hypothesis in doctrine or in practice. Others stated that mortar units were not given the necessary orders and graphics to execute their mission. Again, our data show that this is not a valid hypothesis.

A more basic and overarching hypothesis is that mortars are not integrated into the fire support plan. Here our data required careful analysis. A simple question as to the inclusion of mortars in the plan yields a positive answer. Simple questions lead to simplistic answers. A more careful analysis shows that the mortars were generally *not* included in the fire plan in a meaningful way. This is a major finding of the study.

Military writers have stated that fire support teams and forward observers send most missions to the field artillery. The data we have analyzed support this hypothesis. Even when mortars are in position and available for use, missions ideally suited to their capability are sent instead to artillery units. Another claim against the mortars is that they are inaccurate. Except for the live-fire phases of NTC training, this hypothesis cannot be fully tested from our data. However, our data do show that the actions necessary to ensure mortar accuracy are not being consistently carried out. We have no reason to think that mortar accuracy is inadequate if those procedures are followed. Chief among the neglected procedures is the adjustment of fires when circumstances (inadequate accuracy of target or firing-position location, absent meteorological corrections, etc.) dictate.

It was also claimed that mortar ammunition is inadequately managed. Although we found that the mortars seldom used all the ammunition available to them, we also found that doctrine gives inadequate guidance as to the appropriate munition expenditure required for classes of targets.

CONCLUSIONS

The study concludes that the mortars are indeed underutilized at the CTCs. Yet we found no reason to believe that the CTC environment is the sole or even primary cause of this

underutilization. The most significant shortcoming of the CTCs is their inability to replicate suppressive effects.

We conclude staff planning failure is the prime cause of mortar underutilization. The responsibility for this problem is shared between the maneuver and fire support staffs.

A major factor in mortar ineffectiveness is the failure to adjust fires, as battle conditions seldom support a decision for first round fire for effect.

Physical improvements proposed for mortar systems can contribute to ease and speed of operations, but the observed problems with mortar utilization are not the result of inadequate equipment.

The same comment can be made of doctrine. Some useful improvements can be made, but it is the failure to follow doctrine, rather than the doctrine itself, that underlies the problem. The mortars must be treated as a separate system, carefully integrated into the entire fire support system and not simply added to the inventory of artillery assets.

Training deficiencies in the mortar units themselves are not a major factor in mortar underutilization. Rather, it is the practices of the maneuver battalion and fire support staffs that require improvement.

Finally, we considered organizational changes that might lead to improvement. Although the data do not directly support the hypothesis, arguments can be made that the mortar platoon would be better utilized if the Army returned to its former practice of having forward observers assigned to the mortar unit.

ACKNOWLEDGMENTS

The authors wish to acknowledge the invaluable assistance of the CALL cells at the Combat Training Centers. At JRTC and CMTC, in particular, the CALL staff distributed and collected our data cards and obtained answers to numerous questions that developed in the course of the investigation. The data gathering would have been impossible without the cooperation of the Operations Group observer/controllers at each center, for which we are deeply grateful.

Jerry Sollinger made invaluable recommendations for strengthening the organization of the Note. Jean Carbo and June Kobashigawa have carefully prepared the manuscript for publication. The authors are grateful for their help.

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1. INTRODUCTION

BACKGROUND

In the fall of 1989, the Center for Army Lessons Learned (CALL) at Fort Leavenworth contacted the leader of the Arroyo Center's National Training Center (NTC) research project to solicit participation in a CALL review of mortar operations at the U.S. Army's Combat Training Centers (CTC). At that time the project was finishing a study of artillery accuracy at the NTC [1] and extending the work to another aspect of indirect fires seemed particularly worthwhile.

The CALL's concerns were expressed succinctly in a letter from the CALL director [2] to the observation cells at each of the three maneuver combat training centers (NTC, Joint Readiness Training Center (JRTC), and the Combat Maneuver Training Center (CMTC)). The letter began by stating "Observations and lessons learned from the CTCs continually mention a failure by BLUEFOR to use mortars effectively, if at all." Further, it stated, "Our analysts have identified the following areas of investigation:

a. Command and control as it applies to mortar planning, preparation, and execution.
b. Fire control and distribution, target acquisition, identification and adjustment of fire, ammunition, target battle damage assessment, and percentage of missions fired vs. effects, and satisfaction of commander's intent and attack guidance.
c. Artificialities, safety constraints, instrumentation shortfalls, or other considerations which may be skewing current data."

CALL also directed our attention to the report of Close Support Study Group (CSSG) IV [3], which was convened by the field artillery community to examine various aspects of fire support. Among the topics considered was the future of the heavy mortars. While concluding that the heavy mortars should continue to be fielded in the heavy forces, for the time being at least, several recommendations for improvement were made. Most of these centered on equipment upgrades to improve fire control. When CSSG IV considered the topic of Institutional Mortar Training, the findings were stated to be "Based on the results from the National Training Center, it can be surmised that training on the employment of mortars does not have adequate emphasis. Mortar employment is not totally broken, but all

indications would say it is badly bent." The specific considerations which led to these pungent remarks were not outlined, but this finding certainly supported the CALL position.

OBJECTIVES AND APPROACH

The objectives of our work were to answer the following questions. First, is it true that mortars are underutilized at the CTCs? Second, are CTC results a proper measure of mortar performance? Third, if the answers to the first two questions are affirmative, do current doctrine or training require revision? Fourth, could organizational or equipment fixes improve mortar performance?

We first examined existing data from the NTC that were readily available in the archives at RAND and at the Army Research Institute Field Station at Monterey, California. Following that, we reviewed archived data from the JRTC and the CMTC. Third, we surveyed recent publications dealing with mortars in U.S. Army professional journals.

From those efforts, we were able to determine that there indeed seemed to be a problem with underutilization of mortars at the CTCs, and certain of the published articles suggested hypotheses that might underlie the problem. With this background we devised a set of data cards to be completed by the observer/controllers (O/Cs) at the CTCs after every battle, to explore the validity of these hypotheses.

We expected that these data would describe what the units were actually doing. We also wished to know what doctrine directed or suggested concerning hypothesized problem areas. Therefore we reviewed the doctrine solely directed at mortars, and in addition considered associated maneuver and fire support doctrine.

From these reviews and from the data, we were able to support or refute the various hypotheses and isolate some of the particular causes of mortar underutilization. It was then possible to make recommendations for improving the use of mortars.

EXISTING DATA FROM THE NTC

To gain insights into what particular aspects of mortar utilization might be at the root of the CALL concerns, we first reviewed the data and observations available to us from the NTC, as we were familiar with NTC training and the data archives. We began with the indirect fire logs maintained by the Operations Group during each battle. The heavy mortars belonging to the mechanized infantry and armor battalions training at the NTC are handled through the field artillery control system; we had used the logs in previous studies, including the just completed artillery accuracy study.

The initial data review covered seven rotations for which partial data were available. The mortar data, which are shown in Table 1.1, can be compared to similar data reported for field artillery in Ref. 1 and shown in Table 1.2.

We found that in both offensive and defensive missions, the mortars fired far fewer missions than the artillery, expended substantially fewer rounds per mission, and achieved accuracy results somewhat lower than those found for the artillery (according to the NTC scoring system). Each of these points is explored in more detail in our subsequent investigations. Note, however, that there are many more artillery tubes usually available to support the maneuver unit, with a greater supply capability. A greater artillery firing rate is thus to be expected.

We next reviewed the written Take Home Packages (THP) covering the same rotational time frame. In the fire support sections of the maneuver battalion reviews, we frequently found comments concerning the failure of the mortars to affect the battle. Underlying reasons were not always apparent, but questions of inadequate volume of fire and inappropriateness of target were encountered. We seldom (but occasionally) found comments that indicated that the mortar platoon was unable to deliver fires owing to training deficiencies. For the same cohort of battles, we reviewed available task force orders to understand what missions were assigned to mortars. In about three out of five cases,

Table 1.1

NTC Mortar Firing Data

	Deliberate Attack	Defend Sector
Fire missions/battle (average)	6	9
Percent effective	16	11
Percent suppressive	14	19
Rounds/battle (average)	174	227
Rounds/fire mission (average)	27	24
Other missions (smoke, illumination)	2	0.2

Table 1.2

NTC Artillery Firing Data

	Offense	Defense
Fire missions/battle (average)	46	74
Percent effective/suppressive	39	32
Rounds/battle (average)	2047	4106
Rounds/fire mission (average)	43	55

mortars were deployed by section (and never by squad). They were essentially always kept under task force control. In less than half the battles were firing positions designated in the order, but fire mission assignments were made in 95 percent of cases. Priority of fire was the most common (59 percent) and priority targets were designated in 31 percent of cases. Doctrinally nonstandard missions were called out 29 percent of the time. Means of combat service support (CSS) were specified only 17 percent of the time, but this point may be covered in unit standing operating procedures (SOPs). We found that 64 percent of the fire missions were initiated by team fire support officers (FSOs), and 25 percent by task force FSOs, with the balance by others.

At this point we interviewed the O/Cs responsible for mortar platoon training at the NTC. They confirmed the impressions we had gained from their THP comments that, in their view, the mortar platoons were generally capable of delivering timely fires on targets designated for them. As with any type of combat, combat support, or combat service support platoon, capabilities varied among units, but platoon training shortcomings were not the root of perceived mortar utilization deficiencies. The O/Cs offered a multiplicity of hypotheses as to why the mortars were not more effectively utilized. These valuable comments, together with inputs gathered elsewhere, provided a structure for the data-gathering instruments that we prepared for use in subsequent rotations. Those data are discussed in later sections in this Note and focus more on the relationships between the maneuver and fire support units than on the operations of the mortar platoons themselves.

EXISTING DATA FROM JRTC AND CMTC

The CALL's concerns were not confined to the mortars at the NTC. In Ref. 2, CALL expressed concern for mortar play at the JRTC and the CMTC as well. Our study team was not familiar with data bases at either of those centers. Summary data taken during four rotations at the JRTC helped to orient us on the nature of the perceived problem, which seemed to indicate that the medium (81mm) mortar platoons fired about four missions per battle during a rotation, expending about 13 rounds per mission. Mission effectiveness was shown as less than 7 percent, and caused few casualties. The light (60mm) mortars were used even less, fired fewer rounds per mission, and were generally ineffective.

CALL analyzed the Training Evaluation Outline (TEO) assessments performed by the JRTC observer/controllers during these rotations. The O/Cs found weaknesses in almost all aspects of mortar operations, but CALL was unable to identify specific items that alone could explain the unsatisfactory mortar results. We were left with the belief that there is indeed a mortar problem exhibited at the JRTC but no hypothesis as to the cause.

We therefore examined a sampling of JRTC Take Home Packages from the archives at the Army Research Institute (ARI) field unit at Monterey (ARI/POM). There were summary data for each battle sequence, and both OPFOR (82mm) and BLUEFOR (81mm) mortar data were included. In Table 1.3 we show results averaged over all types of JRTC exercises.

We understood, however, that during the low-intensity phase of operations at JRTC the configurations of the BLUEFOR and OPFOR are dissimilar, which could account for some of the differences shown in the table. Therefore we sifted out and averaged only the missions that might be described as mid-intensity conflict (MIC), where there is greater symmetry between the missions of the respective forces. Results are shown in Table 1.4.

Thus our data show that the BLUEFOR are firing more missions than had been found in the earlier data sample, but that effectiveness was at the same low level. This finding contrasts strongly with the OPFOR results, which show similar firing patterns but much greater effectiveness. Clearly the mortars were not effective; whether they are used at the JRTC to the fullest possible extent by the training unit is a question unanswered by these bare results.

Although CALL was unable to provide us with data from the CMTC concerning mortar utilization, we were asked, and agreed, to include CMTC in the study. There are

Table 1.3

JRTC Mortar Firing Data
(averages)

	81mm	82mm
Missions fired per battle	15	27
Rounds expended per battle	171	299
Average rounds per mission	11	11
Effective missions per battle	1.3	7.4
Mortar KIA per battle	3	30

Table 1.4

JRTC MIC Mortar Firing Data
(averages)

	81mm	82mm
Missions per battle	15	16
Rounds per mission	10	12
Effective missions per battle	1.5	5.3
KIA per battle	3	28

sound reasons for doing so. One argument made by knowledgeable observers of the NTC is that mortars are effective against infantry but that dismounted infantry play at NTC is limited by the nature of the terrain, the scenarios, and the structure of the OPFOR. Thus the relative lack of use of mortar fires might be an expected consequence of the NTC situation. It was pointed out to us during a meeting at the U.S. Army Infantry School that the same argument would not necessarily apply at the CMTC, owing to the nature of the terrain, which includes woods, brush, and occasional structures. It would thus be worthwhile to compare CMTC and NTC findings in this regard. (The argument about infantry play fails completely at the JRTC, of course, where the emphasis is always on infantry.)

We were able to extract some information concerning mortar and artillery utilization at the CMTC from the Take Home Package files at ARI/POM, as shown in Table 1.5.

Table 1.5

Artillery and Mortar Utilization at CMTC (averages)

	FA	Mortars
Missions per battle	25.8	7.2
Rounds per battle	1,284	139
Rounds per fire mission	49.7	19.3

By comparison with data from Tables 1.1 and 1.2, we see that mortar utilization is roughly equivalent at the two centers, although somewhat more rounds are used at NTC. The artillery is used substantially less at CMTC as compared to NTC, although round counts per mission are roughly the same. In Ref. 1 it was pointed out that present-day artillery intensity at NTC has substantially increased over a period earlier in the NTC's history; this is probably due to continued attention to the problem by the FORSCOM/TRADOC training community, as driven by NTC results. Possibly CMTC will experience a similar shift with the passage of time. It is only fair to say that these simple figures alone cannot prove that mortars are underutilized, as we have no information on what additional missions the mortars might have usefully executed. This difficult point will require more detailed examination.

LITERATURE REVIEW

We have noted through the years that problems experienced at the Combat Training Centers have been reported in the professional bulletins of the U.S. Army. We reviewed recent issues of *Infantry, Field Artillery,* and sister publications for comment on mortar training at the combat training centers. We found that several issues have been exposed in

training at the combat training centers. We found that several issues have been exposed in letters and articles written in the past five years. Although the discussion was often vigorous, there generally was no clear identification of underlying problems that would explain underutilization. However two recent reviews of the mortar situation offered specific hypotheses, which gave us a basis for quantitative research.

In an article in *Infantry* in May 1987 [4] the author makes several points about heavy mortars. He refers to the lesser number of mortar tubes in the J-series organization compared with the H-series. He goes on to weigh the advantages offered to the maneuver commander by relying on his own organic indirect fire assets, noting that many commanders do not avail themselves of these advantages. He urges careful selection and specific training for mortar platoon leaders, implying that these points are not always the case in practice.

In Ref. 5, the author discusses the use of the heavy mortar platoon in the offense. He outlines techniques for both the movement to contact and the deliberate attack, but he does not identify outstanding problems with mortar employment. Potential improvements for the heavy mortar carrier (M106A2) are also considered in Ref. 6; but again, the author does not suggest that the mortars are presently unable to function because of equipment deficiencies.

A series of letters to the editor of *Field Artillery* beginning in February 1989 discuss at length the issue of whether the heavy mortars should remain with their maneuver organizations or be reassigned to the field artillery. Interestingly, the discussion has been capped by a letter in the February 1990 issue, which concludes that the Army can no longer afford to keep the heavy mortars in the force. Whereas the combat training center experience is not cited in this lengthy letter, the author's arguments concerning the diminished utility of the heavy mortar in the modern battlefield may encompass the underlying reasons for the perceived underutilization of heavy mortars at the NTC.

Mortars for the "straight-leg" infantry have not been ignored in the literature. The Training Notes section of *Infantry* [7], discusses tactics, techniques, and procedures for use of the 60mm mortars in light infantry forces. In Ref. 8 an argument is presented that calls for the replacement of M60 machine guns in light platoons by 60mm mortars. The conclusions drawn do not rely on training center experience, but on conceptual arguments alone.

In "AOE and the 60mm Mortar," [9] the author argues that the light mortars are handicapped by being undermanned in the present light infantry organization, with negative effects on transport (soldier overload) and fire direction. The author concludes that without augmentation we might best rely only on direct lay methods for the light mortars, with a

consequent diminishment of combat capability. The utility of the mortar is not questioned in the presentation.

A different approach appears in Ref. 10, whose provocative title is "Please Use Me!" The author recounts his NTC experience as an 81mm mortar platoon leader and how his battalion changed the mortars from an underutilized capability to a valuable combat asset during their NTC training. Tactics, techniques, and procedures that were successful are discussed.

Fire support operations at the JRTC are discussed in Ref. 11. The author issues several caveats concerning the 81mm mortars and makes the following statement about the 60mm mortars: "Companies habitually do not employ this fire support asset fully."

This brief review of contemporary thought concerning mortar utilization uncovered several red flags. One would by no means conclude that mortars are broken, as a system. On the other hand, several symptoms of malaise are apparent. Accuracy, for example, was never mentioned as an issue, although we know there are problems in this regard. Planning, coordination, and communication were mentioned in several places. Two subsequent publications [12, 13] offered very specific hypotheses to explain the underutilization of mortars at the CTCs. These hypotheses are outlined below.

HYPOTHESES FOR STUDY

Two possibilities could account for the underutilization of mortars suggested by the data from the CTCs and the literature review. The first is that the mortars have lost their utility on the modern battlefield. Even without a careful historical study of mortar effectiveness, the anecdotal literature contains many references to the deadly effects of mortar fires on infantry units. We would then have to establish a basic change in the nature of ground warfare to support this first hypothesis. This seems unlikely in the case of light infantry but could be the case for the heavy forces. However, early anecdotal reports from Operation Desert Storm report that heavy units continue to successfully employ mortars. We will not theorize further in this regard but will rely on the experience at the training centers.

The second hypothesis is that our tactics, doctrine, equipment, or training are deficient. One senior officer concerned with the preparation of artillery doctrine has offered specific reasons explaining observed problems with mortars [12]. In Ref. 13, the CALL has included mortar issues in a compilation of fire support problems. These summaries offered us a set of specific hypotheses that could be explored using data specially obtained from the CTCs, and these are shown in Table 1.6.

Table 1.6

Some Typical Observations on Mortar Performance

General Employment Issues
Mortars make no contribution; they are not effective.
Communications between the FSO and mortar platoon leader during the battle (are impeded by) limited communications assets.
The effects of mortars are not assessed realistically by the simulation systems used at the CTCs.
Staff responsibilities are not clearly established in doctrine and unit SOPs.
Planning Issues
Mortar platoons do not receive target lists, OPORDs, ACAs, FPFs or priority targets.
Maneuver commanders do not plan final protective fires.
Mortars are not integrated into the fire support plan.
Execution Issues
Company Fire Support Officers do not use mortars.
Fire support teams and forward observers send all missions to the field artillery.
Mortars do not stay within range and are not available when needed.
Mortars are inaccurate; they seldom use surveyed positions and do not apply meteorological corrections.
FSOs do not know which targets mortars are most effective against.
TF FSOs and maneuver S-3s fail to manage mortar ammunition.

SOURCES: "Fire Support Lessons Learned," *Center for Army Lessons Learned Bulletin*, May 1990; "Mortars—Tactical Employment," *Infantry*, September–October 1990.

OUTLINE OF REPORT

One of the basic questions we set out to answer was the suitability of the CTCs for evaluating mortar operations. Section 2 of this report deals with this topic, first describing the mode of replication of mortar fires and then analyzing the validity of the system for research purposes.

For general background, we thought it important that the readers have a common understanding of mortar organization and operations. Appendix A includes those topics.

In Sec. 3 we review and analyze mortar doctrine and the maneuver and fire support doctrine that pertains to mortar operations. Our attention is focused on the hypotheses discussed above and more specifically on issues of tactical employment, fire direction, and target/munition selection.

The acquisition and analysis of quantitative data from the CTCs was a major effort in this study. In App. B, the data instruments and the raw data are presented. The analysis of the data is shown in Sec. 4, and is organized according to the hypotheses listed in Table 1.6. We based our analysis primarily on data from force-on-force battles. Our reasons for excluding the actual data from NTC live fire activity is presented in App. C. In App. D we examine the live fire experience separately for the lessons it might offer.

Conclusions are developed in each of these sections, and the most important are summarized, with suggestions for improving mortar utilization, in Sec. 5. The emphasis is on heavy and medium mortars, as we did not have the opportunity to observe light mortar operations first hand.

2. THE ENVIRONMENT OF THE COMBAT TRAINING CENTERS

The purpose of this section is two-fold. First, we must answer a basic question that led to the study: Is the CTC experience a valid basis for mortar evaluation? If the answer is affirmative, and we wish to properly appreciate and interpret the results of our data, it is then necessary to understand the environment in which the data were taken. In this section, we will discuss those conditions that define the training environment for the mortar platoons and sections at each of the CTCs.

We review the conduct of a rotation at each CTC in "The Typical CTC Scenario." Rather than attempting an exhaustive review of training center operations, we have tried to capture the sense of a rotation or density from the mortarman's perspective. This procedure helps focus our attention on those factors that might impact the mortar's employment.

In "The Replication of Indirect Fires at the CTCs" we define how each CTC currently simulates indirect fires during the course of force-on-force exercises and how they measure the contribution of those fires on the outcome of the battle. We examine several facets of this topic to include how indirect fires are portrayed to the player units and how the accuracy and lethality of those fires are quantified. We not only compare and contrast the procedures in effect at the three CTCs, but we also compare those techniques to methods suggested by doctrinal sources. Throughout this subsection we highlight those concerns associated with the current methods of quantifying accuracy and lethality.

We discuss proposed changes that may significantly alter the manner in which indirect fires are replicated at the CTCs in "Future Developments."

THE TYPICAL CTC SCENARIO

A deployment to one of the CTCs implies several unique training challenges for the mortar platoon. The familiar landmarks of Grafenwoehr and the local training area are replaced by unknown and forbidding terrain, and map reading becomes a critical skill. The platoon is challenged by a thinking, professional OPFOR that is undoubtedly the best trained opponent that the platoon will encounter. At the NTC and the JRTC, the opponent is, in fact, a dedicated asset which has mastered the tactics of the potential enemy units that it replicates. At the CMTC, the OPFOR is composed of units from the same command as the player units. These units receive additional training in OPFOR tactics at the CMTC OPFOR Academy, and they are supported in the field by a team of controllers who ensure that they properly replicate Soviet tactics. Consequently, any lack of experience on the part of the CMTC OPFOR is

probably transparent to the members of the mortar platoon. At all the CTCs, the OPFOR is clearly identifiable to the mortarmen. Each OPFOR wears a distinctive uniform, ranging from the special uniforms worn by both the 32nd Guards Motorized Rifle Regiment at the NTC and the PRAFA forces of the JRTC OPFOR to the reversed protective overgarments worn by the members of the OPFOR forces at CMTC. At the NTC and the JRTC, all vehicles are visually modified to replicate Soviet-built equipment. Armored vehicles at the CMTC are marked with red stars, and Soviet-surrogate armored vehicles have large white drums strapped to the rear of the vehicle to simulate the auxiliary fuel drums on Soviet-built tanks.

Heavy Mortar Training at the NTC

If the mortar platoon deploys to the NTC, it will spend approximately 20 days at that training center. During the first 2 days, the platoon will be busy drawing and preparing equipment. Some mortar platoons draw all their vehicles and equipment from the NTC fleet while others arrive and may need to draw only one or two FDC vehicles. The amount drawn is a function of several variables, including the availability of training funds to pay the cost of transporting the organic equipment from home station. The platoon then deploys with the battalion task force for approximately 14 days of field training. Throughout that period, the mortar platoon will support its parent battalion which, in turn, operates as part of a brigade task force. The deployed brigade normally comprises two maneuver battalions and a complete "brigade slice," which includes the Direct Support Field Artillery battalion, the Forward Support battalion, an Engineer company, an Air Defense Artillery (ADA) battery, an Attack Helicopter battalion, a Signal Platoon, a Military Police (MP) platoon and a U.S. Air Force (USAF) Tactical Air Control Party. Consequently, the mortar platoon is controlled and supported just as it would be in actual combat. The mortar platoon leadership must coordinate all logistic support through the Headquarters Company (HHC) executive officer and must realize that the delivery of food, water, and needed supplies can be interrupted by the actions of the aggressive OPFOR or the confusion created by unforgiving terrain. Both vehicular and personnel casualties, though certainly simulated, require actual evacuation and a realtime wait for replacements thus highlighting the mortarman's awareness of the role of several staff support elements. The habitually assigned forward observers (FOs) and fire support teams (FIST) deploy with the task force as does the battalion FSO. Hence, the normal fire support channels are functional and standard fire support coordinating procedures are in effect.

Of the 14 training days, approximately 4 to 5 days are dedicated to a series of live-fire battles while the remaining days are spent conducting force-on-force exercises. While one battalion task force is involved in live-fire exercises, the second task force is conducting force-

on-force exercises. The two task forces then switch roles and the unit conducting live-fire training moves to the force-on-force exercises. The last three force-on-force battles are normally conducted as brigade-level operations, but that change may be transparent to the mortar platoon. On average, each task force participates in nine battles, of which six are normally force-on-force operations and three are live-fire exercises. The type of battles that are conducted reflect the unit's Mission Essential Task List (METL) and normally include movement to contact, hasty attack, defense in sector, deliberate attack, and hasty defense. The order and frequency of these battles is based on coordination between the player unit chain of command and the NTC Operations Group. The rotation schedule allows for preparation time, especially prior to "deliberate" operations, which may require significant intelligence-collection activities and the construction of obstacles and fighting positions. From the mortarman's perspective, a "battle" usually lasts about four hours and the remaining time is spent maintaining equipment, rehearsing plans for the upcoming battle, preparing positions, recovering damaged vehicles, and participating in AARs. The length of an NTC rotation makes it a very demanding exercise and creates significant demands on the mortar platoon, not the least of which is the need for an effective sleep plan.

During the live-fire exercise, the platoon is issued actual ammunition and is required to observe all the same safety regulations that apply at the home station. However, during the dry-fire exercises these restrictions are lifted, and the platoon can fight exactly as it would in actual combat except for the absence of live ammunition. For example, during the live-fire exercises, the mortars cannot fire over the heads of friendly soldiers, a restriction that imposes unrealistic positioning requirements. This restriction is not required in the dry-fire exercises and efforts are under way to eliminate it from the live-fire exercises. During the force-on-force exercises, paper rounds simulate actual munitions. The unit can fire only those rounds that have been issued to the unit and delivered to the firing element. Ammunition is distributed by issuing the appropriate number of paper sheets to each mortar squad, and it is prestocked by physically placing the sheets in the squad ammo pit. Ammunition is consumed by turning in the number of paper sheets that corresponds to the number of rounds fired. To be resupplied, the unit must adhere to its own SOPs and submit the appropriate ammunition request in a timely manner. Sufficient vehicles and manpower must arrive at the ammunition transfer point (ATP) to transload and haul the issued munitions. Vehicle capacities are outlined in the Rules of Engagement [15, 16], and units are not allowed to exceed those capacities. An ammunition transfer rate of one round per man per minute imposes a realtime delay on the unit while they remain at the ATP loading paper ammunition.

One of the most noticeable differences between training at the NTC and at the home station is the presence of the observer/controllers (O/Cs). At the NTC, mortar platoons are controlled by a team of two E-7 NCOs, who have recently completed assignments as mortar platoon sergeants. The mortar platoon O/Cs are the training center subject matter experts on mortar operations. They remain with the platoon throughout the entire rotation, although different teams will accompany the platoon through the live and dry-fire phases of the rotation. These O/Cs monitor the activities of the platoon and use their observations as the basis for the AARs that follow each battle. They have access to both the Task Force plan and the O/C control net and can therefore correlate the activities of the platoon to the events on the battlefield.

Heavy Mortar Training at CMTC

The 4.2-in mortar platoon that deploys to the CMTC will face many of the same challenges confronted by the platoons at the NTC. Forced to maneuver on unfamiliar terrain, each convoy and displacement becomes a unique challenge. As mentioned earlier, there is an OPFOR that wants to outmaneuver and outwit the BLUFOR. Most important, the ever-present O/C team accompanies the platoon throughout that portion of the training density which the platoon spends in the maneuver area. The structure of this O/C team, as well as the entire Operations Group, mirrors that of the NTC. The NCOs on the mortar team are highly qualified, experienced mortarmen who are extremely well-versed in the operations of a mortar platoon. They enter the fray armed with an event scenario and a control gun and can usually deliver several significant training lessons with little difficulty.

From the mortarman's viewpoint, however, there are several significant differences between the two training centers. First, during the force-on-force battles, the resupply of ammunition is not a paper exercise. The CMTC uses ammunition boxes to simulate actual rounds. These containers replicate the weight and cube of the actual rounds and clearly require the unit to expend manpower, time, and vehicle support to effect resupply. Second, there is no live-fire exercise at the CMTC, and the entire time in the maneuver area is spent in force-on-force exercises. Third, there is no equipment pool at the CMTC so the platoon must use its own equipment to fight the war.

A fourth and, perhaps, key distinction between the NTC and the CMTC is the nature of the terrain. The NTC is a large, flat desert plain interrupted by several prominent mountains and ridges. While maneuver forces can be canalized in certain areas, the excellent trafficability throughout the training area supports the high-speed tactics of large armored and mechanized forces. The mortar platoon in training at the NTC might expect to

conduct frequent displacements in support of rapidly advancing forces. Firing positions must be selected to exploit the cover provided by the wadis and folds in the terrain. On the other hand, the CMTC, located in the forests of Bavaria, is characterized by broken, hilly terrain which many feel is more appropriate for dismounted infantry activity. Ground mobility is restricted to valleys and existing roads and trails because the dense forest and moist ground conditions preclude cross-country movement by armored forces. Platoons in training at the CMTC have no difficulty finding well-concealed firing positions. One hypothesis argues that the restrictive terrain slows the tempo of the battle, precludes frequent displacements, and creates dismounted infantry targets. However, we found little difference in the utilization rates of the mortars at each CTC. We have, in fact, been briefed that little dismounted activity occurs at the CMTC and that most battles are fought as a contest between armored vehicles. Consequently, the expectation of a pronounced difference in the amount of mortar fires at the CMTC is not realized.

Finally, the structure of a density at the CMTC is markedly different from an NTC rotation. The CMTC density typically consists of three distinct phases. During any one phase, one task force is in the maneuver area conducting force-on-force operations while the leadership of the second task force is participating in the war through the computer-based Integrated Brigade and Battalion Simulation Exercise (IBBS). This allows the Brigade headquarters to control two task forces at any given time. While the leadership of the second task force is involved in this computer simulation, the assigned mortarmen are conducting platoon-level training. A third task force may be in a separate designated training area conducting independent unit-level training. Only the Task Force conducting force-on-force operations in the maneuver area is under the critical eye of the O/C teams. Each task force has the opportunity to participate in each of these phases during the course of a typical rotation. On average, each phase lasts approximately 5 to 6 days; the length of the density for the units observed in this study was 23 days.

As at the NTC, the schedule of events for the CMTC density is Mission Essential Task List (METL) driven. During the training in the maneuver area, a mortar platoon can expect to participate in four battles, which may include movement to contact, defense in sector, hasty attack, and deliberate defense. To assist in the conduct of those operations and to provide needed support on the battlefield, the task force has access to the full support of a typical brigade slice. For the members of the mortar platoon, the actual battle typically lasts about four hours. As at the NTC, time between events is spent conducting a variety of recovery and preparatory operations to include the evacuation and replacement of vehicles and men.

Mortar Training at the JRTC

The environment at the JRTC is much more fluid than at the other CTCs. The 81mm mortar platoons and 60mm mortar sections that deploy to the JRTC face many of the same challenges as at the other CTCs, such as the unrelenting OPFOR, the unfamiliar terrain, and the ubiquitous O/Cs. Both the 81mm mortar platoon and the infantry company 60mm mortar sections have dedicated O/Cs. However, the structure of the typical rotation is much more flexible and responsive to the variety of units that utilize the facility. The 11-day, force-on-force scenario can be tailored to meet the needs of a Ranger battalion conducting a long-range search and destroy operation, an Airborne Infantry battalion conducting a night operation to seize and hold an airhead, or a Light Infantry battalion conducting a reconnaissance in force. Units can be tasked to conduct either forced or non-forced entries into the exercise area and will confront an OPFOR capable of replicating forces appropriate for both low- and mid-intensity conflict. The "package" that deploys for training to the JRTC is also extremely variable. The task force and its supporting elements are normally tailored to meet the training objectives of the rotation. Typically, however, both the medium and light mortars accompany and support the parent battalion task force. The FOs, FIST and fire support element attached to the task force also participate as a part of the deploying force. They can access either real or notional supporting artillery and naval gunfire units; the fire support channels are operative and normal fire support coordination procedures are in effect. Support for the mortar elements is provided by the appropriate sections of the Task Force and all ammunition resupply is simulated using ammunition containers, similar to the method employed at the CMTC.

Light Mortar Training at the NTC

In response to an Army training initiative, Heavy/Light Force Integration Improvement, the NTC has initiated both "heavy-light" and "light-heavy" rotations. Unlike more traditional training rotations that tend to pit like-type forces, these exercises require heavy and light forces to operate in a complementary fashion to accomplish the mission. Typically, a heavy brigade headquarters deploys with one or two heavy maneuver task forces and a light battalion is attached to it. During FY90, four of the rotations at the NTC were heavy-light exercises, while one rotation was a light-heavy exercise in which a heavy maneuver Task Force was attached to a light brigade headquarters. We observed one light-heavy and two heavy-light rotations, which allowed us to observe the light mortars in a markedly different environment.

By their very nature, these rotations are unique training events for the deployed mortar elements. Not surprisingly, there is an O/C team specifically tasked to control the

activities of the light units. Called the "Tarantulas," they are the "light-fighters" of the NTC and normally field an O/C team, which controls the activities of the organic 81mm mortar platoon. Augmentee O/Cs are required to control the company 60mm mortar sections. Each mortar platoon and section must carry a "manpack," which allows the Core Instrumentation Subsystem to identify the point of origin of all indirect fire missions. Ammunition issue and resupply for the 81mm mortar platoon is simulated using paper rounds similar to the procedures for the 4.2-in mortar platoon. Ammunition for the 60mm mortar sections, however, is simulated by sand-filled canisters that must be delivered to the section to enable them to fire. The rotation lengths match that of a traditional rotation, and the typical variety of battles is conducted: defense in sector, deliberate attack, hasty attack, and movement to contact. However, the nature of the enemy portrayed by the OPFOR as well as the scope of the assigned mission are adjusted based on the particular characteristics and capabilities of the light unit.

Two aspects of these rotations may affect on the light mortar elements. First, the controlling brigade may not be familiar with the logistic requirements of the light unit and may not, for example, be accustomed to forecasting and ordering either 81mm or 60mm ammunition. The limited availability of transportation assets may impact resupply of the mortar units. Second, the fire support coordination procedures normally practiced at home-station may be revised on the first day of the war. If the light unit deploys, as expected, with its habitually attached FOs and FSOs, then those fire support teams will have to resolve any procedural differences and coordinate communication assets with the direct support (DS) field artillery battalion from the heavy division.

THE REPLICATION OF INDIRECT FIRES AT THE CTCS

Realistic portrayal of the effects of indirect fire on the training battlefield has long been a justified concern of Army trainers. In an environment where indirect fire systems are not portrayed or only partially replicated, soldiers may become cavalier about the devastating effects of indirect fire systems. In such an environment, the effectiveness of fire plans cannot be verified and the potential contributions of fire support systems may be ignored. If the systems are inaccurately portrayed, commanders and planners may conclude that, at best, the contributions of indirect fire systems are only marginal and not worth the time and effort expended in integrating those systems into the battle plan. In light of this concern and the objectives of this study, it is necessary to review how indirect fire systems are portrayed at each of the CTCs. This review will address two issues. First, we will examine how the actual delivery of indirect fires is simulated. Second, we will compare and contrast how each CTC determines the accuracy and lethality of indirect fire missions.

The Firemarking Process

An indirect fire mission can be viewed as an iterative process in which each iteration requires three sequential activities. The three activities of one iteration include:

1. Actions by the Forward Observer. Those actions necessary to identify the location and nature of the target and to transmit that request to the appropriate indirect fire support agency. In subsequent iterations, this step includes identification of the correction necessary to move the point of impact of the rounds closer to the target.
2. Actions by the Controlling Fire Direction Center. Those actions necessary to process the mission and translate the observer's request or corrections into fire commands that can be executed by the fire delivery system.
3. Actions by the Delivery System. Those activities required to aim and fire the particular weapon system.

The number of iterations depends on the type of mission fired. A "fire-for-effect" mission requires a single iteration while an "adjust-fire" mission requires repeated iterations of the process. The "product" of this sequential process is the arrival of indirect fire munitions on the identified target. In order to have that product appear at an appropriate point in time and space, certain actions must be initiated by the O/Cs and analysts.

We will now review those actions required of both the player units and controllers to simulate indirect fires. We will then discuss certain considerations associated with this process.

The actions by the Forward Observer are simulation-free but not necessarily entirely realistic. At each CTC, the individuals who identify a target during the force-on-force exercises cannot always employ currently available equipment to identify the target location and to transmit that information to the appropriate Fire Direction Center. In fact, observer teams that are equipped with laser-locator-designators are prohibited from using them because of the possibility of eye injury to unprotected soldiers. As a result, observers use the low-tech devices that have been a part of their kit-bag for many years—a compass, a map, a radio, and a set of binoculars—despite limitations in target location accuracy.

There are no constraints on the Fire Direction Centers (FDCs), which process the fire mission data as if it were for an actual live-fire mission. Whether the platoon or section FDC employs the Mortar Ballistic Computer, manual fire charts, or the M16 Plotting Board, it must generate and transmit complete fire data to the mortar tubes. The FDC must ensure

that the generated technical solution is constrained by all effective fire support coordination measures and simulated available ammunition stocks.

Little deviation from actual procedures is evident during the actions by the delivery system except for the use of simulated ammunition, which we have already addressed. Mortar crews are expected to actually orient the tubes on the generated firing data and to simulate actions necessary to cut a charge and load and fire a round.

When the mission is received at the mortar FDC, each CTC initiates their particular process to simulate indirect fires. At the JRTC, the Mortar Platoon O/C notifies the Fire Marking Control Center (FMCC) that the platoon FDC has received a fire mission request. Included in that notification is the stated location of the target, the type and amount of ammunition requested, and any other requirements, such as a specific time-on-target. The FMCC will then notify one of the firemarker teams to move to the approximate location of the target. At the JRTC, these firemarkers are civilian contracted personnel who are expected to provide coverage for specific portions of the training area, supplemented by O/C firemarking when necessary. The firemarkers remain in constant radio contact with the FMCC and periodically report their location to that control center. Once in position, the firemarker awaits additional instructions from the FMCC. A very similar process is in effect at both the CMTC and NTC. At the CMTC, the Vampire Training Team is responsible for manning the Artillery TAF (Training Analysis and Feedback Facility), which controls a team of approximately 20 active-duty firemarkers who are deployed throughout the training area. The Artillery TAF attempts to preposition the firemarkers based on the fire plans generated by the player units with the intention of clustering the firemarkers in areas expected to receive the majority of indirect fire. Once the Artillery TAF becomes aware of a firing mission, a firemarker is notified by radio to move to the approximate location of the target and await further instructions. At the NTC, the Operations Group also fields approximately twenty active-duty soldiers as firemarkers. O/Cs located at the mortar platoon FDC transmit target and mission information to the analysts located in the Operations Center who, in turn, enter the data into the Core Instrumentation Subsystem (CIS). These analysts position firemarkers on the battlefield and direct them to the reported target grid. At all the CTCs, the O/Cs accompanying those elements that may be in the vicinity of the target are also notified so they can assist in the timely assessment of casualties.

O/Cs carefully monitor the transmission of the fire commands to the guns. If data has been generated and the tubes "fire" that data, then the O/C notifies the controller who, in turn, directs the firemarker to expend pyrotechnics at the requested target location to simulate indirect fires. If the tubes do not receive the data, if the data is grossly inaccurate, or if the

tubes are not laid using correct procedures, the O/C will notify the appropriate firemarker controller not to mark the mission. O/Cs do not routinely attempt to verify the exact accuracy of all data generated by the platoon FDC. Rather, they rely on their experience to ensure that the data is reasonable based on the range and direction to the target.[1] One difference in operational procedures among the three CTCs is identifiable during this stage. The JRTC is the only CTC that uniformly attempts to recreate the explosive sound generated by all indirect fire systems. At that CTC, one grenade simulator is expended at the mortar firing position to simulate the conduct of a fire mission, no matter how many rounds are fired. One mortar O/C team at the CMTC employs firing simulators whereas the second team does not. At the NTC, the noise of artillery weapons is simulated but currently no effort is made to simulate that of mortars.

Once the firemarker is notified that the mission is to be marked, he expends a certain number of pyrotechnics at that target location as specified in the Casualty Assessment Tables, based on the number of rounds fired. As stated in a previous RAND study [1], these "simulators by no means represent the full impact of the (mortar) rounds, but they do yield a visual and acoustic signature that indicates to fire callers and maneuver elements where and when indirect fires have fallen." Once the firemarker has fired the pyrotechnics at the reported target location, the process of simulating the delivery of indirect fires is complete.

Several observations are necessary concerning the firemarking process. First, the estimates of the time required to complete this process vary. The pre-rotation training brief [14] published by the Fire Support Trainers at the NTC states that "the average time between the report of shot and the mission's marking currently runs at two and a half minutes." Artillery Controllers at the CMTC report that the average response time between the moment when the mission is received in the control cell until the impact is displayed is three minutes. Information from the JRTC indicates that the expected time for a mission is two minutes. Many analysts are confident that the firemarking process as described is a fair representation of the actual mission process (e.g., the process at the NTC provides round-on-target simulation quicker than the average time required for missions conducted in live-fire exercises). In addition, several analysts have also indicated that every effort is made to have O/Cs assess casualties at the expected time of impact even if the firemarker is not in position to simulate the impact.

Second, at each CTC, the number of firemarkers in the field depends on the rotational unit's training scenario. During critical training periods, the maximum number of firemarkers

[1]The JRTC has moved to have the firemarkers discharge pyro at the place the rounds would have landed, calculated according to the erroneous firing conditions used by the unit.

are available, but during those periods between major events firemarkers leave the training area for necessary rest and resupply. Some O/Cs have commented that this policy has an impact on the player units' ability to conduct registrations and other preparations before the battle. Others argue that there are always sufficient firemarkers in place to respond to any unit request.

Third, we have outlined a single iteration of the fire mission process that would correspond to a *fire-for-effect* mission. Should the delivery unit decide to *adjust fire* on the target, then repeated iterations are required wherein the firemarker is expected to adjust his position according to the size of the correction applied to each subsequent round and to mark the point of impact of those adjusting rounds with pyrotechnics. Only when the platoon O/C reports that the unit has entered the fire-for-effect phase of the mission does the firemarker use the quantities of pyrotechnics specified in the Casualty Assessment Tables. Such a mission would obviously require the dedicated effort of a firemarker for a longer period of time.

Finally, the ability of the firemarker to accurately identify the correct target location varies among CTCs. At the JRTC, the firemarker's ability to determine his own location as well as the location of targets is a function of his experience and the availability of several identifiable control points scattered throughout the training area. The JRTC has now received and issued Global Positioning System (GPS) devices to the firemarker teams, which will enhance their ability to determine grid locations accurately. At the CMTC, the ability of the firemarkers to correctly identify target locations also depends on the firemarker's experience and the availability of approximately 70 control points scattered throughout the training area. While the firemarkers at both CMTC and JRTC are no doubt well trained and familiar with the training areas, human error and the difficulties of navigation in bad weather or darkness may degrade their accuracy. At the NTC, each firemarker vehicle is equipped with an instrumented player unit (PU) component that allows the CIS to determine the firemarkers' location to the nearest 10 meters. The analysts can thus quickly direct the firemarker to a target location and be sure that the firemarker is prepared to simulate the fires at the exact location requested.

The Determination of Accuracy and Lethality

The distinction between firemarking and the determination of accuracy and lethality is not an arbitrary one. As the Werewolves argue in their pre-rotational briefing [14], "casualties are assessed independently of firemarking," and the number of casualties assessed is clearly a function of the platoon's ability to accurately put rounds on the target and the capability of those rounds to cause damage and destruction. We will now examine the procedures used at each CTC to gauge the accuracy and effectiveness of the mortars in order to assess casualties.

Accuracy Considerations. A review of the firemarking process outlined above should lead the reader to the conclusion that the firemarker simulates indirect fires at the target location defined by the observer in the call for fire. As argued in a previous RAND report [1], the underlying principle defining accuracy at each of the CTCs is that "the rounds land where the call for fire specifies." Although such an operating procedure may be necessary to ensure the timely replication of indirect fires, it does tend to overstate the capability of the mortar system by ignoring several factors that affect the accuracy of that system and that often become obvious in the live-fire battles.

Obviously, any error in the determination of the firing point grid should result in rounds missing the target by a similar distance. During force-on-force exercises, this is a two-part problem. First, the O/C must recognize the error and second, a penalty for the error should be imposed. Each CTC, however, addresses this problem differently.

The capability to detect a location error varies among CTCs for the same reasons that affect the firemarkers' ability to locate targets. O/Cs at the CMTC have had to rely on their knowledge of the terrain and available control points to verify the accuracy of the grid location reported by the player unit FDC but have now been issued GPS receivers. At the JRTC, O/Cs also rely on their knowledge of the terrain, and GPS units are being issued to assist in this verification process. At the NTC, the same instrumentation system that can accurately locate firemarkers also aids the O/Cs in confirming the location of firing platoons. Every FDC is equipped with a PU which communicates location data to the CIS. O/Cs can access this data to verify the reported location of the platoon FDC.

Once a location error is detected, there is no uniform standard in effect among the O/C teams for penalizing player units. One team at the NTC reports that it allows the unit to fire and casualties to be determined despite any error in the grid location of the firing point. The error is discussed in the AAR but has no effect on firing accuracy. A second team indicates that it allows the platoon's fires to generate casualties if the discrepancy between the reported location and the actual location is less than the dimensions of the Indirect Fire Casualty Assessment System (IFCAS) box which measures 600m by 260m. If the location discrepancy exceeds those dimensions, then the team attempts to coach the platoon leadership and encourage them to recompute their location grid. If the player unit fails to respond to this coaching, then the O/C coordinates with the TAF to offset the IFCAS box a distance equal to the error in the grid location of the firing point, thereby degrading the accuracy of fires. This latter approach appears to be the norm at both the JRTC and the CMTC. At those CTCs, if the platoon erroneously locates its firing position, then the O/C reports that information so the firemarker can offset the target location by a corresponding distance.

Except at JRTC, this appears to be the only element of accuracy, beyond a target location error by the FO, actively considered during the force-on-force exercises. Other considerations that have a significant impact on the mortars' ability to fire accurately (the declination of aiming circles, the registrations, the requirement to boresight, and the utilization of MET data) may be discussed during the AAR but are sometimes ignored during the actual replication of impacting rounds. At JRTC these errors are included in the fire-marking process, if possible.

The CMTC has attempted to formally define a set of rules to reduce the effect of those units that fail to address certain basic accuracy considerations. Outlined in the CMTC Rules of Engagement [15] these apply primarily to the field artillery player units but could extend to the mortar player units as well. These rules address almost every ingredient for accuracy. Several samples follow:

> In order to provide more realistic battlefield effects, based on the accuracy/ proficiency of firing platoon operations, the following areas have been assigned relative values. When any or a combination of these areas are found to be deficient (in an amount equal to or greater than a factor of 5), then the accuracy of the fires for the unit will be adjusted accordingly.
>
> (1) Orienting station incorrectly entered into the BCS/BUCS/or manual chart: For errors over 200 meters, accuracy of fires will be effected immediately (or assessed a value of 5 points). No survey or an ORSTA error of less than 200 meters will result in the unit being assessed 1 point.
>
> (5) Failure to declinate Aiming Circle and Advance Party compasses. Unit will be assessed 1 point.
>
> (c) Failure to boresight when occupying a new position or when the tactical situation allows: 1 point.

Unfortunately, there is no published table that defines how the accuracy will be "adjusted accordingly." In the event of gross error, the O/Cs have the option of offsetting the firemarker or reducing the number of casualties generated. However, there is no calibrated standard for degrading effects. Although such a standard may prove too cumbersome to impose on a non-automated training environment, it would certainly reflect the appropriate concern for those actions that must remain routine for any indirect fire system. Perhaps an easily enforced system, uniform among the CTCs, which degrades effects based on inaccurate procedures, should be considered.

Lethality Considerations. The determination of lethality reflects even greater operational variance between CTCs. In fact, the CTCs do not even share a common definition of an *effective* mission. We will now review the assessment process, highlighting the differences between CTCs.

The casualty assessment process can be considered a two-step procedure. First, analysts identify the mean area of effectiveness of the mortar rounds and the number of enemy elements within that area by type and degree of protection provided. Second, analysts use this information as well as the number of rounds fired and the published Casualty Assessment Tables to determine casualties.

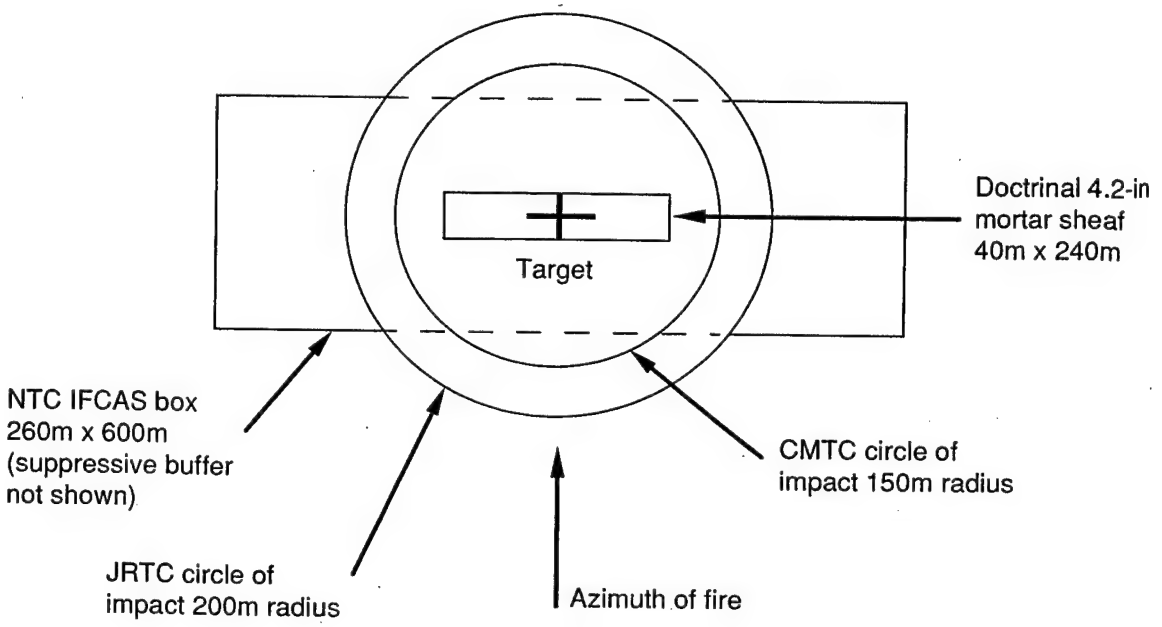
DETERMINING THE MEAN AREA OF EFFECTIVENESS

As mentioned earlier, the point of impact is the requested (or adjusted) target location. The mean area of effectiveness (MAE) defines the boundary of that region in which impacting rounds are assumed to have an effect on the target. The point of impact is assumed to be the geographic center of the MAE. At the JRTC, the MAE for both 60mm mortars and 81mm mortars is defined as a 100m radius circle (31,500 square meters). For the 4.2-in mortar system, as well as all field artillery and naval gunfire weapons, the MAE was a 200m radius circle, but is now 100m for all mortars, according to recent information. At the CMTC, the MAE is defined as a 150m radius circle (70,700 square meters). This is the standard dimension for all indirect fire weapons systems deployed at the CMTC, to include the 4.2-in mortar, the M109 155mm SP howitzer, and the M110 8-in SP howitzer. At both CTCs, the dimension of the MAE is not adjusted for the number of rounds fired or the number of tubes participating in the mission. At these two CTCs, both the firemarker and the O/Cs identify any enemy elements located in the area of impact and report that information to the control cell for use in the assessment of casualties.

At the NTC, controllers use the computer instrumentation system to generate an IFCAS box for each mortar or artillery mission. During the period of this study, the original computer display system was used, as described here. Subsequently, a new computer system has come into use which differentiates between indirect fire systems. The old IFCAS box was a rectangular area measuring 260m by 600m (156,000 square meters) for all mortars and artillery. The center of the IFCAS box is determined by the reported grid to the target, and the IFCAS box is oriented so that the long side of the box is perpendicular to the azimuth of fire of the delivery system. Enemy elements within this IFCAS box are liable to become casualties. Those enemy elements within 500 meters of the IFCAS boundary are considered to be suppressed. The area encompassed by the IFCAS box and the suppressive buffer zone is

approximately 1.8 square kilometers, covering nearly two standard grid squares. The CIS allows the analysts to monitor the location of player units and to determine their location in comparison to the IFCAS box and the suppressive buffer.

Figure 2.1 compares the different standards imposed at each CTC to define the MAE for a 4.2-in mortar platoon. Also depicted in the figure is a standard doctrinal platoon sheaf, assuming a 20m bursting radius per round per tube for a 6-tube 4.2-in mortar platoon.



Location	Size of 'Area of Impact'
CMTC	70686 square meters
JRTC	125664 square meters
NTC	156000 square meters
Doctrinal sheaf	9600 square meters

Fig. 2.1—Comparison of Mean Areas of Effectiveness for 4.2-in Mortar Platoon As Defined by Each CTC

It is both interesting and significant that the standards for this MAE not only vary between CTCs but also differ from the standards defined by doctrine. ARTEP 7-90-MTP, entitled Infantry Mortar Platoon, Section and Squad, specifically outlines two methods for determining if the fire-for-effect rounds are effective. The first method requires a trained individual to observe the impact of the rounds to determine their relative proximity to the reported target. This clearly subjective technique has little utility during a force-on-force ESX. The second technique employs survey teams or a radar section to conduct flash/radar plotting to determine the actual point of impact of the fired rounds. Once that point of impact is identified, the effectiveness of the mission is determined using a quantitative approach. The CMTC area of effectiveness corresponds to the MTP standard for a 4.2-in mortar platoon.

ASSESSING CASUALTIES

At all three CTCs, an analyst/controller requires certain information to assess casualties. This requirement includes the number of rounds fired by the particular weapon system and the number, type, disposition and protection of the enemy elements located within the area of impact. As we have discussed, player unit information at the NTC is provided by the Core Instrumentation Subsystem. At the other CTCs, the information is verbally reported by the firemarkers and O/Cs within the vicinity of the impact.

Provided with this information, the analyst can enter the Casualty Assessment Tables that are included in the CTC Rules of Engagement (ROE) [15, 16]. These tables are provided to the player units at both the NTC and the CMTC but are not issued to those units training at the JRTC and, in fact, are not included in the JRTC ROE. A sample of one assessment table currently in effect at the NTC and CMTC is shown in Table 2.1 [16].

The analyst selects the appropriate table, matches the number of rounds fired against the target type and degree of protection and determines the number of casualties to be assessed. That information is passed to the appropriate O/Cs and firemarkers to "kill" the corresponding number of players and equipment.

At this point, the process becomes subjective, particularly at the CMTC and the JRTC, as the firemarkers and O/Cs must visualize the MAE on the ground and select appropriate casualties. At the NTC, the analyst can execute an "admin kill" through the CIS; however, it is perhaps more effective to allow the O/C, who is more aware of the element's performance, to identify victims. Certain vehicles, for example, may have taken advantage of some natural cover and concealment and would be less vulnerable to the effects of indirect fire. An effective mission at the NTC is one in which enemy elements are in the IFCAS box, whether

Table 2.1

NTC/CMTC Casualty Assessment Table Extract HE Casualties for 60mm, 81mm, 4.2-in Mortars, 105mm, 155mm, 203mm Artillery

Rounds	6	12	18	24	30	36	42	48	54	60	66
Type Target											
Troops in open platoon	1	2	3	4	5	5	5	5	5	7	8
company	4	4	7	11	14	18	18	18	21	21	27
Troops dug in (no overhead)											
Platoon	—	—	1	1	1	1	2	2	2	3	3
Company	—	—	4	4	4	4	7	7	7	11	11
Troops dug in (with overhead)											
Platoon	—	—	—	—	—	1	1	1	1	2	2
Company	—	—	—	—	—	4	4	4	4	7	7
Artillery	—	—	—	—	—	—	—	—	1	1	1
Armored Personnel Carrier	—	—	—	—	—	—	—	—	1	1	1
Tanks	—	—	—	—	—	—	—	—	—	—	—

or not they are killed. At the CMTC and the JRTC, a mission is called effective only if casualties are generated.

At all CTCs, the concept of effectiveness is applied only to those mortar missions employing high explosive (HE) munitions. Smoke and illumination missions, which can very effectively support the commander's concept, are not measured against any similar grading scale. This definition also ignores those HE missions which effectively shape the battlefield or in some other manner implement the commander's intent but do not actually inflict casualties.

As the ROE states, these tables are "simplified unclassified approximations of Joint Munitions Effectiveness Manuals" and are probably based on data appropriate for those heavy weapon systems that were expected to be routinely deployed at the NTC. A comparison was conducted between the entries in the assessment table and the Graphical Munitions Effects Table (GMET-JMEM) for medium field artillery which is, in fact, a derivative of the JMEMs for training use. Table 2.2 summarizes some results from this comparison.

One of the primary concerns associated with these casualty assessment tables is oversimplification. The title of the sample shown in Table 2.1 provides a clue to the simplification involved. That table consolidates the data for HE missions for 60mm, 81mm, and 107mm mortars as well as 105mm, 155mm, and 203mm artillery. Thus, according to these tables, 24 rounds fired on an infantry platoon in the open will result in 4 casualties whether those rounds were fired by one 60mm mortar tube firing at the sustained rate of fire or a battalion of 8-in field artillery howitzers firing *one round in effect*.

Table 2.2

Comparison of GMET & NTC Casualty Assessment Table

Target—29-Man Enemy Platoon in the Open

Rounds fired	Casualties by GMET	Casualties by NTC tables
36	3	5
54	6	5
90	9	10

Target—29-Man Enemy Platoon Dug-In

Rounds fired	Casualties by GMET	Casualties by NTC tables
54	1	1
108	3	4

A second concern is the existence of different tables at the different CTCs. We were informed that a decision was made in early 1990 to standardize the tables to mirror those in use at the NTC. However, as of this writing, the JRTC is employing different tables. The JRTC tables discriminate by weapon system caliber and by the number of tubes firing the mission and yield different results than the NTC/CMTC version. For example, a 60mm mortar section firing 6 rounds per tube at a company in the open is awarded 4 casualties at the NTC. The same mission at the JRTC generates 8 casualties. While it is certainly not clear which table is correct, the lack of a common standard tends to defy logical explanation.

A third concern is the absence of these or similar tables in appropriate doctrinal manuals. The CMTC ROE recommends that "units should determine their attack criteria on the basis of the JMEM, GMET or TACFIRE solution." However, units simply do not routinely use the JMEM as a source of attack guidance. TC 6-40, entitled *Field Artillery Manual Cannon Gunnery,* argues, in fact, that the "use of JMEMs at battalion and battery FDC levels for engaging targets of opportunity is not recommended" due to the JMEMs' "volume, lack of accessibility and by the difficulty in comparing ammunition or weapons systems." Certainly, this advice is appropriate for the mortar platoon. Unfortunately, the mortar platoon does not have access to either a GMET or the TACFIRE solution. Current doctrine is void of sufficient specific guidance for target effects planning. ARTEP 7-90 MTP discusses time and accuracy standards for fire missions in detail but never identifies a standard for attack criteria. FM 7-90 (draft) discusses mortar weapons effects and offers one specific example of attack criteria, but that example contradicts current CTC tables. It proposes that "against a platoon-sized enemy unit, a 60mm mortar section that fires three rounds per mortar should inflict about 30 percent casualties." Assuming that an enemy

platoon consists of 29 soldiers, the 60mm section that fires 6 rounds should be assessed approximately 9 casualties. According to the data in Fig. 2.1, however, such a fire mission is awarded 1 casualty at the NTC; at the JRTC the same fire mission produces yet a different number of casualties. It should come as no surprise, therefore, that most platoons observed in training attempt to rely on the information in the Casualty Assessment Tables to determine the appropriate attack criteria.

A final concern is the failure of these tables and the Rules of Engagement at any of the CTCs to fully address the notion of suppressive fires. Suppressive fires disorient the enemy, limit his ability to continue his mission, and create confusion and apprehension. This is, however, a difficult, if not impossible set of conditions to replicate in a training environment. Mortars are considered to be ideal for delivering suppressive fires, and the inability to "play" this capability may be precluding this system from fully demonstrating its potential. At the NTC, there is a suppressive buffer around the IFCAS box and a mission is defined to be suppressive if enemy elements are within the boundaries of that area. However, there is no efficient means of replicating suppression of those enemy elements and temporarily degrading their ability. Both the CMTC and JRTC lack any formal mechanism for defining suppressive missions. Both players and O/Cs have frequently commented on this issue and have offered a variety of options, such as removing the antennas from certain vehicles or forcing drivers to button-up and reduce speed. However, there is currently no calibrated standard for replicating suppressive effects. Consequently, the mortar platoon that fires 54 rounds at a platoon in the open may kill a BMP. If the same platoon fires only 48 rounds, nothing happens even though everyone recognizes that the platoon's progress should be slowed.

FUTURE DEVELOPMENTS

It is encouraging to report that both the CTC leadership and the fire support community have not ignored the issue of the accurate replication of indirect fires at the CTCs. Several developments confirm that these agencies are committed to improving the simulation of all indirect fire systems.

First, as we mentioned earlier, a decision was reached to standardize the Casualty Assessment Tables at each CTC. While the implementation of this decision has not yet been fully achieved, such a standardization will certainly eliminate an illogical flaw in the system.

Second, fielding the Hellfire Ground Support System (HGSS) Laser Designator Rangefinder remains a priority concern. This device is designed "as a direct field replacement for training purposes for the Ground/Vehicular Laser Locator Designator

(G/VLLD)" and provides FIST teams with an eye-safe laser that should enhance their effectiveness during force-on-force exercises at the CTCs. According to information received from the United States Army Field Artillery School (USAFAS), a decision was made on 31 July 1990 to procure and issue 260 HGSS sets. The basis of issue for these devices includes distribution to each divisional unit as well as to Forts Benning, Knox and Sill. The NTC is scheduled to receive 13 sets while the JRTC will receive 5 HGSS sets. Sixty-four sets are slated for issue to USAREUR and ultimately, for use by units at CMTC. Follow-on Testing and Evaluation is scheduled for September, 1991 and Initial Operating Capability is programmed for September, 1992.

Finally, the current fielding of the Combined Arms Training Integration Evaluation System (CATIES) at the NTC will markedly change the manner in which indirect fires are replicated. CATIES has three components, including a master computer, numerous actuator stations, and player unit appliques. The master computer broadcasts a signal to the various actuator stations throughout the training area that an indirect fire mission is being conducted. The NTC has over 50 such actuator stations currently in place. Based on information transmitted from the master computer, these actuator stations will transmit a signal to the appliques mounted on those player unit vehicles located within the defined target area. The size of the target area will vary based on the caliber of the weapon firing. Once the applique on the vehicle receives the transmission, it will use established probability data to determine whether the vehicle is a hit or a near miss. If the vehicle is a hit, the vehicle's MILES system will be activated. In either case, a flash-bang-smoke device will be detonated on each vehicle that creates the audiovisual cue for the soldiers in the simulated indirect fire impact area. Currently, appliques are available and mounted on vehicles in the NTC fleet and are being developed for wear by the individual soldier. Operational testing of the CATIES system will be conducted in conjunction with future rotations.

To provide the CATIES master computer with a target area size that considers the caliber of the firing weapon, the NTC has redefined the IFCAS box for all indirect fire systems. For field artillery systems, the IFCAS display that is fed to the CATIES master computer will be circular if the unit fires the BCS sheaf. For the 155mm howitzer, for example, the NTC selected the BCS display with aim points 75 meters from the target so that the dimensions of the IFCAS display is a circle with a 125 meter radius. Similar circular IFCAS boxes of different dimensions have been developed for all caliber artillery. If the unit does not fire a circular sheaf, as is the case for mortars, a rectangular IFCAS box is fed to the CATIES master computer. The NTC has designed an IFCAS box for the 107mm section, which encompasses 7,200 square meters and for the platoon, which encompasses

14,400 square meters. Both of these represent a significant reduction in the mean area of effectiveness for the 107mm elements. In fact, in comparison to the MAE depicted in Fig. 2.1, the area of these IFCAS boxes represent an order of magnitude reduction in the size. It will be most interesting to track the effectiveness of the mortar systems in future battles as the more restrictive MAE are enforced.

The NTC and USAFAS have also developed revised Casualty Assessment tables for use with CATIES that account for the number of tubes firing and the number of rounds fired. These extensive tables closely track the data in the JMEMs. A quick reference device is also being developed that will allow for the manual assessment of casualties should CATIES fail. This device is expected to be a caliber-specific "whiz-wheel," which simplifies those tables developed in support of CATIES. It will be designed for field use and will be available for use by player units or be considered for publication as a doctrinal training aid similar to the GMET.

CATIES will not be fielded at either the JRTC or the CMTC. Instead, those CTCs will field the follow-on system entitled Simulation of Area Weapons Effects-Radio Frequency (SAWE-RF), which employs the same concepts as CATIES but relies upon satellite support in lieu of actuator stations and exploits the expected availability of GPS equipment. CMTC is scheduled to field SAWE-RF in 1992 and JRTC will implement the system in 1993. The CATIES system currently being fielded at NTC is, in fact, scheduled to be replaced by SAWE-RF in 1994.

CONCLUSIONS

The conclusion of our examination is that the CTCs do form an adequate framework for the evaluation of mortar utilization. The biggest drawback of the CTCs in this regard is their inability to consistently replicate the effects of suppressive fires.

Additionally, many of the elements that influence mortar accuracy (e.g., charge cutting, accuracy of tube laying, etc.) are not factored in during force-on-force battles; but one could consider the results obtained in such a study to define an upper limit on what would take place in actual combat situations.

A substantial drawback for heavy mortar training at the CTCs is the relatively low emphasis on dismounted operations, both by the BLUEFOR and the OPFOR, where mortars might be expected to make their most significant contribution.

3. MORTAR DOCTRINE

We have examined both published doctrine and some manuals still in preparation that cover the utilization of heavy, medium, and light mortars to compare doctrine with the practices of training units at the three CTCs. We want to know whether some of the difficulties we see in the field result from failure to apply doctrine correctly or stem from incomplete, misdirected, or even missing doctrine.

We did not focus on the technical aspects of mortar gunnery because we have no reason to believe that technical gunnery problems cause the perceived lack of mortar utilization and effectiveness. Some platoons are more adept at gunnery than others, but gunnery (with the exception of failure to register or adjust fires) does not appear to be the root of the mortar problem. This observation holds particularly true in the force-on-force exercises, where many aspects of gunnery are not accurately tested, yet mortar effectiveness is less than desired.

The initial reviews of battle results, supported by later data taken in the field, yield two laments arising from the parent task forces and the mortar organizations themselves. The task forces' viewpoint is that the mortars do not seem to influence the battle; the mortar units' viewpoint is that the mortars are not being called on to do very much. These views are fairly consistent. Therefore our interest is in the tactical roles and modes of employment of the mortars. In particular, we looked at organization, command and control links, fire planning, and fire control as well as the missions assigned to the mortar units as part of fire plans.

Several of the hypotheses listed in Table 1.6 suggested particular points for our doctrine review. For example, we wanted to see what doctrine recommended in terms of platoon vs. section employment. Following that, the issue of task force control as contrasted to operational control (OPCON) or attachment to subordinate units seems fundamental in planning the role of the mortars. It is unlikely that the mortars will fulfill a need in the battle if that need is not anticipated and included in the fire plan. What does doctrine suggest? Even the issue of what can realistically be expected of mortar fires must be clearly understood by the maneuver leaders as well as those responsible for fire support. What guidance resides in doctrine? To obtain answers, we have reviewed the spectrum of the doctrinal literature.

DOCTRINAL LITERATURE REVIEWED

Tactical doctrine for mortars can be found in several series of manuals. FM 7-90 is a manual published by the Infantry School titled *Tactical Employment of Mortars*. We have examined both the published version, dated 1985, and draft versions dated December 1989 and June 1991. However, mortars are but a part of a combined arms team, so we have also looked at maneuver unit manuals. Included in this review are the published versions of FM 71-1, *The Tank and Mechanized Infantry Company Team* and FM 71-2, *The Tank and Mechanized Infantry Battalion Task Force*. We have also reviewed a coordinating draft version of a proposed manual, FM 71-123, *Tactics, Techniques, & Procedures for Combined Arms Heavy Forces*. Two sets of manuals deal with non-mechanized infantry units: FM 7-70, *Light Infantry Platoon / Squad*; FM 7-71, *Light Infantry Company*; and FM 7-72, *Light Infantry Battalion*. Another more general series of infantry manuals includes FM 7-10, *The Infantry Rifle Company (Infantry, Airborne, Air Assault, Ranger),* which we have reviewed in published form (1982); a draft version (dated March 1990); and FM 7-20, *The Infantry Battalion (Infantry, Airborne, and Air Assault,* 1984). A maneuver commander might also seek guidance for the employment of mortars in certain Field Artillery manuals created for maneuver elements, e.g., TC 6-71, *Fire Support Handbook for the Maneuver Commander*. We have reviewed versions of FM 6-20-40, *Fire Support in Brigade Operations (Heavy)* and FM 6-20-50, *Fire Support for Brigade Operations (Light).*

These manuals cover the gamut of mortar utilization, and it is not our purpose to summarize all aspects of the topic. Rather we are interested in those specific areas where mortar operations seem to be having difficulty. These include accuracy, volume of fire, effectiveness of fires, organizational responsibility, command links, integration into the maneuver unit fire plan, and other specific topics. We have chosen to organize this section into reviews of tactical employment, technical fire control, and weapon effects.

TACTICAL EMPLOYMENT

In the review of tactical employment, we divide the discussion into heavy mortars (4.2-in), medium mortars (81mm), and light mortars (60mm). We begin with FM 7-90 in each discussion and then sift through the maneuver manuals as appropriate to the particular mortar. In this way contradictions and omissions can be readily identified. It should be remembered that FM 7-90 is written to cover all sizes of mortars and all supported units. Thus the tactical guidance there should be somewhat general. That is not true of the manuals that deal with the supported units. If clear and explicit guidance for maneuver

units is not given there, it will not exist and units will be left to stratagems of their own construction.

Heavy Mortars

Our review was first directed to the use of heavy mortars, as present in tank and mechanized infantry battalions. Regarding organization, the 1985 version of FM 7-90 states that the heavy mortar platoon can be employed by platoon, section, or squad. It is clear from the discussion that control by squad will not be commonly seen, and the circumstances for section versus platoon arrangements are outlined. It goes on to say that the mortars should remain under parent unit (battalion task force) control unless the platoon cannot support subordinate units in that mode. This might be the case if a subordinate unit requiring mortar support were given an independent mission, for example. It also says that attachment is to be avoided, suggesting that OPCON is preferred when the mortars are placed with subordinate units (company teams). There is a possibility for conflict in understanding of this point in the present version of the manual, but the new coordinating draft has clarified the circumstances.

Tasks assigned to mortars in support of the maneuver battalions must be in the context of the task force missions; most task force missions at the NTC or the CMTC can be described as movement to contact, hasty attack, deliberate attack, or defend in sector. For each of these missions FM 7-90 offers general guidance for use of mortar fires, whereas FM 71-1 and FM 71-2 should offer more specific guidance for the use of the mortar platoon. We found that FM 71-1, the company team manual, contains only a few general points about mortar employment. FM 71-2 is therefore the central maneuver manual as far as the heavy mortars are concerned. For example, it is clearly stated that during movement to contact "The task force mortars are placed under the operational control of the advanced guard to provide responsive fires and smoke to support initial actions on contact" (p. 3-46). This guidance appears to be reasonable in our view. The security screen, which has priority of fires according to doctrine, is too far ahead of even the advanced guard to permit adequate support by the mortars. The advanced guard, which has the task of making initial contact and developing the situation, is apt to need fires on demand. By using the OPCON mode, the reliability of communication and avoidance of delay in the fire support chain is enhanced; the advanced guard commander and his FSO can go directly to the mortar platoon with greater assurance that the platoon will be where they need to be to provide the support. In these circumstances, it seems logical that the mortars would operate as a platoon, not as

independent sections (although they might move as sections), to better coordinate movement and to concentrate fires.

Our data indicate that the OPCON mode is seldom if ever employed at the NTC or CMTC nor do we find the mortars being given the specific mission of supporting the advanced guard. Thus this important and sensible guidance is being ignored.

The draft of the proposed manual FM 71-123 discusses to the need for decentralized artillery (p. 3-20) with direct (linked) communications during a movement to contact, but it does not mention mortars in the discussion because this section covers brigade operations. However, even in the battalion section on move to contact (MTC) the mortars are barely mentioned.

Turning to the hasty attack, FM 7-90 observes that most mortar fires will be on targets of opportunity, but does not discuss the command relationships that might be preferred. This treatment is not amplified in the new coordinating draft. FM 71-2 states that "Mortars are placed under the control of the FSO to provide general support to the battalion. Priority of support is to smoke operations to facilitate maneuver." We observe that if the task force has been maintained in a disciplined formation to permit the massing of combat power, the mortars should be able to range over the battalion sector to provide the necessary support. However, our data do not show that smoke is the most common use of the mortars during hasty attack. We cannot say whether the doctrinal guidance is best. Taking another tack altogether, draft FM 71-123 suggests that mortars move in sections behind the scouts during hasty attack (p. 3-108). However, this cannot yet be viewed as doctrine. We suspect that the guidance of FM 71-2, stating that the mortars are best used to provide immediate smoke (and perhaps suppression) is the best advice, although others may differ.

Guidance for the deliberate attack is different yet. FM 7-90 speaks of mortars delivering "massive, precisely timed fires on specific targets" and goes on to say that the mortar platoon leader should consider registration among other things. FM 71-2 states "Mortars move well forward with the main effort" (p. 3-57). However, it also says that delivery of smoke is the prime mission for the mortars. Again, there is a discrepancy between manuals. In either case, although it is not explicitly called out, we expect that the mortars should support as a platoon and that they might be OPCON to the unit conducting the main attack. Our data indicate that the mortars are essentially never placed OPCON to a subordinate unit. The FM 71-123 coordinating draft offers a somewhat different perspective. In the general guidance for deliberate attack, the role of mortars is not specifically mentioned. However, in one example the mortars were included in a grouping

called the supporting force during the conduct of a breaching operation. This seems a useful distinction and clarification of a potential mode of mortar employment.

Although FM 7-90 contains detailed discussion of general mortar capability in the defense, it properly does not address how commanders should set priorities. The manual discusses the customary indirect fire targets, such as obstacle coverage and the disruption of advancing columns. In addition it discusses two other specific roles. One is support of the security force, and the other is support of antitank units. We have not encountered these discussions in other places. In its treatment of defensive operations, FM 71-2 offers no specific guidance for the mortars in the section on combat support. However, in the section on synchronization (p. 4-25) it says that "The battalion mortars are initially deployed to support a secondary avenue of approach. Their alternate mission is to provide responsive smoke to support the maneuver of company teams between battle positions." We note that the first mission might be enhanced by placing the mortars OPCON to the unit having responsibility for the secondary avenue(s). However, it may be necessary to have them revert to task force control to carry out the alternate mission. In practice, our review of operations orders shows that the mortars are almost never specifically assigned to support secondary avenues.

However, another version of doctrinal guidance for the defense is emerging in the proposed FM 71-123, where it is suggested that the mortars support counter-reconnaissance activity in the sector, and then prepare to cover the whole sector by split sections during the defense. This proposal contrasts with FM 71-2, which recommends that the mortars support a secondary avenue of approach and would probably not require operations by split section. Use of mortars to provide smoke during withdrawals is also mentioned. These sometimes conflicting concepts between the draft FM 71-123 and FM 71-2 should be reviewed and resolved. Intuitively, the concept of having the mortars concentrate on one avenue seems more appealing than having them try to cover a battalion sector.

In closing the review of heavy mortar doctrine, we examined FM 6-20-40. Because this volume was prepared by the Field Artillery School to help with the general problem of fire support, it is not surprising that the mortars receive only limited attention. While mentioned in various parts of the main body of the manual, the mortars are specifically addressed in an appendix. Guidance for application is almost absent, but command relationships are discussed in some detail and organization (platoon, section, squad) is discussed in more detail. Readers are cautioned that mortar fires often must be adjusted. The statement is also made that the doctrinal responsibility of FSOs toward mortars is limited to recommending their integration into the fire support plan. The manual explains

how the FSO might assign mortar priorities in defensive operations, but there is no parallel discussion for offensive operations.

Medium Mortars

The general guidance afforded by FM 7-90 also applies to the infantry units that employ the medium (81mm) mortars. User units include non-mechanized infantry of all types. The maneuver manual that applies to all such battalions is FM 7-20. However, the existing version is six years old, and the revision has so far been unavailable for our review. The existing version has few specific instructions for mortar employment. For example, it states that the mortars should be well forward in an MTC to support the lead elements (p. 4-18), but for other offensive situations the guidance is extremely general. In defensive situations, the manual states that the mortars are normally given supplementary instructions (in addition to the general instruction of giving close and continuous fire support) by allocation of priorities of fire and priority targets. What is not made explicit is what those priority missions ought to be.

The section on Fire Support states that usually the commander will retain control of the mortars but will normally assign priorities to a company, thereby providing responsive support. It then points out that the mortars must position themselves so as to be able to support the company with priority of fire. The section also discusses the circumstances under which alternate command relationships are appropriate. The manual makes it clear that the commander or the S-3 plans the general locations of the mortar platoon in coordination with the platoon leader. Here the possible role of the FSO is not mentioned.

A new series of manuals has been created for the light infantry divisions. We have reviewed FM 7-72 for its treatment of battalion mortar platoon utilization and found few specific considerations. For example, it is suggested that the mortar platoon move with the main body during an MTC while keeping the ability to range forward of the lead elements (p. 3-15). Because of the limited speed and more compact formation of a light battalion as compared with a mechanized battalion, this guidance seems appropriate and consistent with what we have previously reviewed. The role of the mortars is mentioned in example scenarios of offensive operations, although only general statements are made concerning mortars in the discussions of defensive operations. There is no specific consideration given to mortars in the Fire Support Appendix.

We have found that the company-level manuals for infantry concentrate on use of the light mortars, rather than on how the medium mortars might be used for company support.

Light Mortars

FM 7-90 gives very little special attention to the 60mm mortar and its employment. However, the latest draft revision includes a chapter titled "Special Considerations for the 60mm Mortar Section." This chapter contains a very detailed treatment of light mortar employment in the various offensive and defensive actions that may be required of an infantry company. Therefore we have looked for consistency between this draft manual and the appropriate maneuver manuals.

In the portion of FM 7-90 devoted to the light mortars, a great deal of attention is given to such vital matters as ammunition transport. Issues of firing position selection and movement are also explored. There are fairly detailed treatments of the use of the company mortars during movement to contact, and hasty and deliberate attacks. Similar detailed treatment is given to defensive operations.

We have reviewed the appropriate maneuver manuals to ascertain their consistency with the guidance offered in FM 7-90. As noted previously, we have examined the 1982 edition of FM 7-10, the infantry rifle company manual, but found almost no specific guidance for the use of the 60mm mortars. This is not true for the revised coordination draft currently being reviewed, which pays more attention to guiding mortar employment. For example, positioning during movement is discussed (p. 3-4), and it is made clear that the mortars must not be placed at the rear of the company if responsive fires are to be expected. Instruction for use of the mortars in overwatch is given (p. 3-16). There is guidance on MTC for mortar utilization and possible measures for ammunition carriage. Later in the section on the offense, the use of the company mortars during an attack is discussed. The issues of ammunition transport and security for the mortars are emphasized (p. 4-33). The treatment is quite consistent with the guidance given in FM 7-90, although the latter is generally more detailed.

The manual discusses positioning of the mortars in a defense (p. 5-15), coverage of the company sector, and issues of range. The duties of the mortar section sergeant in setting up a defense are set forth (p. 5-23). Thus we find that this manual is making a particular effort to call out the role of the mortars in various combat situations.

Additionally two further general sections apply to the mortars. One is on fire support in Chapter 7 (Combat Support); the other is Appendix E (The Company Mortar Section). Many points on mortar planning, as well as general fire support considerations, are covered in Chapter 7. One aspect emphasized on page 7-23 is the need for adjustment of fire in many combat situations. Appendix E includes a summary of the employment roles and displacement modes for the mortar section, consistent with the discussions in the body of the

manual. This appendix has the characteristic of being a summary version of the 60mm mortar appendix in FM 7-90. This new version of FM 7-10 will be useful to company commanders and company mortar leaders alike in integrating the mortars into the combat team. But this doctrinal guidance is missing from the available mortar and general infantry manuals. The reader is reminded that it is the draft version of both of these manuals we have been discussing. Not only may it take some time to complete the review and publication process, but additional time will elapse before the new treatments are incorporated into the training and operations of the fielded forces.

The situation is slightly different for the published light infantry manuals. FM 7-71, "Light Infantry Company," deals with the company mortars. There is extensive treatment of *how* to organize, manage, and move the mortars, and it is consistent with guidance given in drafts FM 7-10 and FM 7-90. There is, however, little coverage of *what* the mortars are expected to accomplish in various combat situations, that is, their tactical utility. This same comment might be made of the treatment of the company mortars in FM 7-70 "Light Infantry Platoon/Squad." Section III of Chapter 7 in FM 7-70 describes the mechanics of employing the mortars and calling fires, but the maneuver chapters make little or no mention of mortar employment. These observations are consistent with what we have discovered in the field—the problem is not that the mortars do not know how to shoot; the problem is that of directing them to shoot at something.

For completeness we have reviewed FM 6-20-50, prepared by the Field Artillery School for the guidance of light maneuver units and their fire supporters. When mortars are mentioned in the manual, it is usually to point out their value in providing responsive fires in the situation being discussed.

The text does not dwell on mortar utilization, however. The characteristics of mortars, command relationships, and organization are discussed in an appendix devoted to fire support assets.

FIRE PLANNING AND EXECUTION

We have focused on the tactical employment aspects of mortars. The techniques of planning and executing fires will also influence the effect the mortars will finally have on the battlefield. Chapter 5 of FM 7-90 explains the standard artillery system of planning so that the mortarmen can be integrated into and understand the fire plan. However, one dissonant note sounded immediately in our review. In the manual, the mortar platoon is urged to do what is necessary to prepare for first round fire-for-effect missions on planned targets. Field data indicate that the mortars are seldom called on to fire planned targets; moreover, they

almost never have accurate firing locations and meteorological data that would enable them to shoot accurately without registration or adjustment. The former point may change if the fire support community alters its mode of utilization of the mortars; the latter point is physical and will not change in the immediate future. We emphasize this issue in another part of this section; however, in the draft version of FM 7-90, this particular problem is avoided. It is our view, based on field data and artillery doctrine, that the mortars must adjust fire in almost all circumstances, and that this point should be addressed directly in every doctrinal discussion of mortar utilization.

The published version of FM 7-90 specifically addresses the alternative communication nets that mortar platoons and sections might employ. The new draft version presents a somewhat more detailed discussion, and weighs the pros and cons of alternative configurations. Our field data indicate this issue can have a significant effect on enhancing the use of mortars. The various maneuver manuals do not treat this subject in any detail; some do not mention communication nets for the mortars at all. Artillery doctrine and artillery practice are apt to dominate the architecture of the fire control nets in any combined arms organization. Mortars are often included simply as another unit of artillery, and in practice mortar fire direction nets are often taken over by the battalion FSE.

If the oft-stated doctrinal viewpoint that the mortars are the commander's most responsive fire support asset is accepted, the state of affairs outlined above is not satisfactory. Responsiveness is not simply a matter of laying tubes and shooting quickly, and it is not clear that the mortar advantage is decisive. Responsiveness is more apt to be enhanced by expedited decision and communication links. This result is best obtained by linking the anticipated user directly to the firing units. Although sacrificing potential flexibility in applying mortar fires, this method ensures responsiveness. Such a practice may not be appropriate to every situation, but according to our review of doctrine it is to be expected frequently. For those cases, the doctrine should make clear the preferred command, control, and communication links.

An Example of Mortar Integration into a Fire Plan

The issue of integrating the mortars into a fire plan is discussed yet seldom defined in the literature. To some, apparently, the issuance of a fire support matrix with mortar priorities of fire and possibly a few priority mortar targets satisfies the concept of integration. However such a matrix does not guarantee use of the mortars at all; it simply states some priorities.

Our definition of the integration necessary for effective use of mortars goes much further and requires specific taskings, command and control linkages, and movement plans. We offer the following paragraphs as an example of the level of detail in a portion of a fire plan that we feel is necessary to assure effective utilization of the mortars:

> The mortars will be OPCON to Team Bravo (the breaching force) during movement from the LD and during the breaching operation. Mortars will revert to TF control on order. Mortars will occupy firing position M-1 to support breaching operation. Bravo FIST, using mortar FD-1, will order mortar smoke on obstacle system SNAKEPIT when Bravo lead elements pass PL THUNDER. On initiation of breaching operation, Bravo FIST will lift mortar smoke on SNAKEPIT and initiate mortar smoke and HE suppression fire on enemy positions in Objective PIANO. Bravo FIST will adjust as necessary. Continue through breaching operation. Shift mortar fires to Target AIB once lead elements of the TM A (assaulting force) clear passage lanes and initiate assault. Continuous coverage is important; maintain dispersion to avoid counter-fire. COLT team 7-77 is placed OPCON to Bravo FIST to act as back-up.
>
> 1-23 FA will smoke PL THUNDER between grids NK 294422 and NK 289424 on order from Bravo FIST as Bravo lead elements pass PL LIGHTNING and until lead elements reach PL THUNDER and will subsequently prepare to provide on-call fires and counter-battery fire on suspected enemy firing positions near Objectives DUD and STUD. Bravo FIST will cue FIREFINDERS at initiation of breaching operations, using battalion fire support net (voice).
>
> Fire support rehearsal will be combined at the TF TOC at 14:30. Voice net rehearsal will be conducted with TF rehearsal. Mortar platoon FDCs will participate. In addition to basic load of WP on carriers, 150 WP rounds will be transported to forward mortar positions by battalion support platoon.

The above paragraphs represent a fire plan that supports the commander's intent of protecting his breaching force from enemy indirect fires using artillery assets, while protecting the breaching force from direct fires in part through use of mortar smoke and suppression. The plan is explicit enough that a meaningful rehearsal is possible, and the role of each element in supporting commander's intent can be clearly understood. Our experience in reviewing doctrinal manuals (dealing with a variety of subjects) suggests that exemplary

material added to the directive text can be very effective in conveying the intent of the instruction, and we recommend such additions to the manuals dealing with mortars.

Responsibility for Integration of Mortars in Fire Support Plan

A hypothesis included in our list for examination is that responsibility for the integration of mortars into the fire plan is not clearly established in doctrine. We have found the three following quotes in the manuals shown. These cover mortar doctrine, heavy battalion maneuver doctrine, and fire support doctrine.

> FM 7-90: The mortar platoon has no formal planning responsibility, other than the technical computation of firing data and insuring commander's guidance is met.
>
> FM 71-2: The task force commander and his FSO integrate the firepower of mortars . . . with the maneuver of combat units.
>
> FM 6-20-40: The FSO's doctrinal responsibility is limited to recommending the integration of mortars into the fire support plan.

These instructions are entirely consistent and make it very clear who is responsible for what. Therefore the hypothesis presented is not valid as far as doctrine is concerned. Unit SOPs of course may differ.

TECHNICAL FIRE CONTROL

The field artillery community has expended a great deal of effort in attempting to achieve an accurate, first-round, fire-for-effect capability. Such a capability has obvious benefits, including increased effect on the target as surprise is achieved, reduced ammunition expenditure, and reduced vulnerability to firing units from hostile target acquisition assets. According to TC 6-40, there are five ingredients necessary to achieve first round fire-for-effect accuracy. These ingredients are depicted in Fig. 3.1 and are applicable to any indirect fire source to include the three mortar systems studied.

The first ingredient is accurate computational procedures, i.e., the computed firing data must be error-free. The Mortar Ballistic Computer has eliminated the introduction of human error (except for keying errors), which often played a significant role in the manual computation of firing data. Unfortunately, this ability is the only ingredient for accurate first round fire-for-effect the mortar units possess.

As a weapon system that fires high-angle missions with a long time of flight, a mortar is particularly vulnerable to the effects of weather. TC 6-40 clearly argues that the "effects of

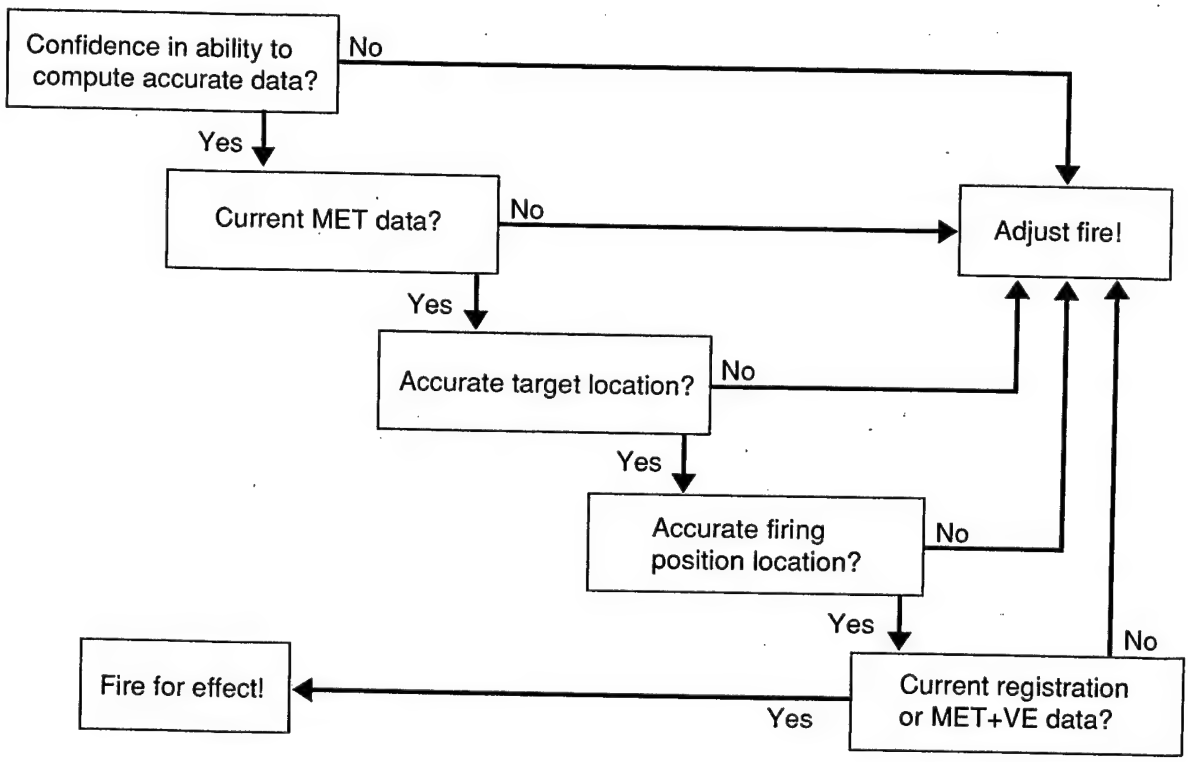


Fig. 3.1—Criteria for "Adjust Fire" vs. "Fire-for-Effect" Missions

weather on the projectile in flight must be considered, and firing data must compensate for those effects." Unfortunately, it appears unrealistic to expect a mortar unit to receive a correctly formatted current MET message, which is one of the key ingredients for accurate first-round fire-for-effect data. MET messages are created by the MET section organic to the division artillery or the FA brigade headquarters. They normally prepare the message type required by the TACFIRE computer system, that is, the computer met message recorded on a tape readable by the TACFIRE computer. This version of the MET message is not, however, readily compatible with the MBC.

The next two ingredients are similar in that they address the problem of location determination, in particular, the ability of the forward observer to accurately identify the location of the target and the ability of the mortar platoon leader to accurately identify the

location of the firing platoon. The ability of the FO to accurately identify a target's location is discussed in great detail in a RAND Note [1], which concluded that it is unreasonable to expect an unassisted observer to achieve a mean target location error of less than 500 meters. In addition, data contained in that same report indicate that the mean error in self-location is approximately 180 meters. This is significant as the mortar platoon is not equipped with very sophisticated equipment to accurately determine the location of the firing position. A map, compass, and aiming circle comprise the tools readily available to the mortar platoon leader (until GPS is added to platoon equipment). The position and azimuth determining system (PADS), which is an essential tool during the conduct of a position occupation by a field artillery platoon, is usually not available to support the mortar platoon. Hasty survey techniques, which could reduce the location error, are not discussed in the current version of FM 7-90. A draft version of FM 7-90 recommends the use of hasty survey techniques to minimize location error and also recommends, if possible, the use of friendly artillery radar to accurately locate the firing position.

Finally, the unit must be able to either measure the performance of the firing weapon or conduct a registration. The field artillery firing battery is expected to gain accurate muzzle velocity data for each howitzer in the platoon by using the authorized M90 velocimeter. However, mortar platoons are not authorized a device of similar capability, yet mortar tubes are subject to the same factors that affect muzzle velocity—barrel wear, new weapon tolerance, etc. In fact, FM 23-91 states that "if a battalion armed with new mortars fired with a common lot of ammunition, a velocity difference of 3–4 meters per second between the mortar with the highest muzzle velocity and the mortar with the lowest muzzle velocity would not be unusual." Hence, one would expect mortar units to conduct frequent registrations. Depicted in Fig. 3.2 is the decision process to determine whether or not a registration is necessary. The logical conclusion from both charts is that mortar platoons should routinely conduct registration missions or should only fire adjust fire missions.

EFFECTS OF FIRES

Every issued fire order must include the type and amount of ammunition to be fired in support of the mission. When Field Artillery units are working in the automated mode, the TACFIRE computer system determines the number of rounds to fire based on information in the computer database, utilizing whatever commander's modifications have been entered. When these units are required to work in the manual mode, the Joint Munitions Effectiveness Manuals (JMEMs) are available to determine attack criteria. However,

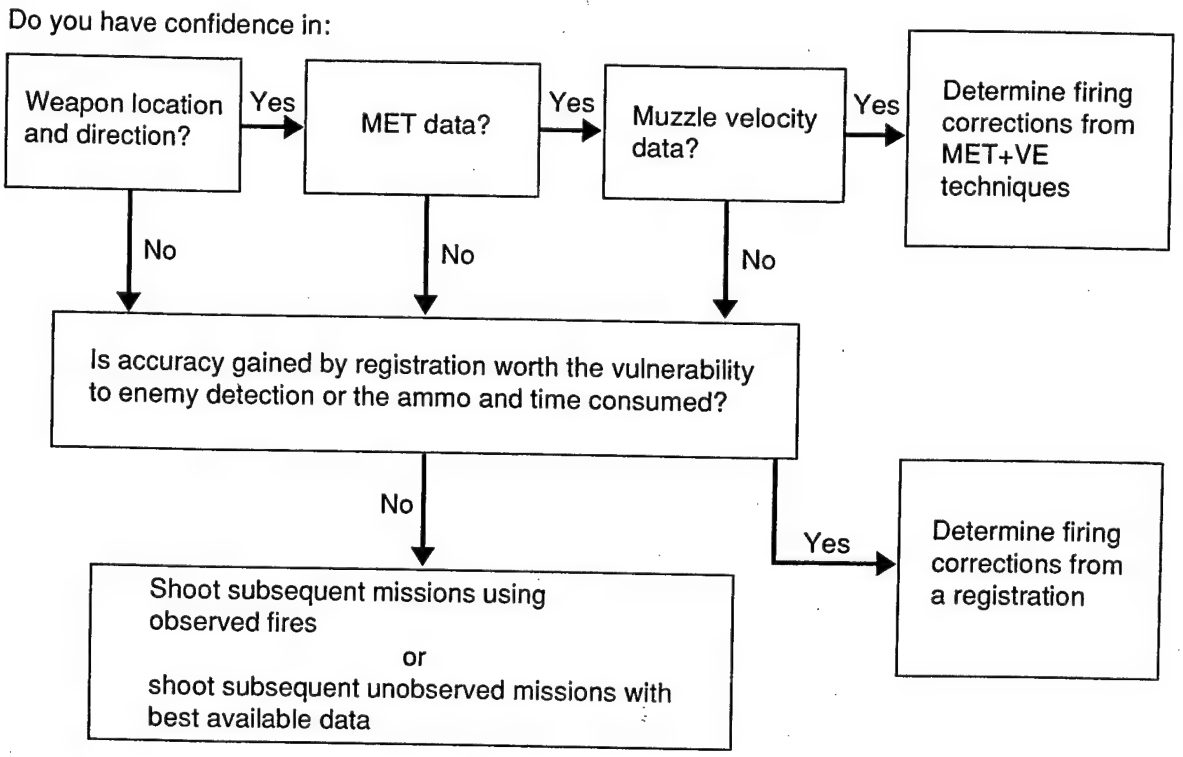


Fig. 3.2—Registration Decision Diagram

TC 6-40 clearly argues that these volumes are not recommended for use in the field. In fact, the manual recommends that the unit use the condensed version of the JMEMs known as the Graphical Munitions Effects Tables (GMETs). These are "slide-rule" versions of the JMEMs that allow rapid determination of the number of volleys required to achieve a specified casualty rate. Unfortunately, no similar device or table exists for the mortar platoon. FM 23-91 does include a discussion entitled "Amount and Type of Ammunition," but it provides no definitive guidance on how to determine the amount of ammunition required to achieve a particular effect on the target. Table 2.3 of the same text is entitled "Targets and Methods of Attack," which identifies the most effective shell and fuze combination but does not give guidance for the number of rounds or volleys required.

The 1985 edition of FM 7-90 has little coverage of the effects of the various mortar rounds. The latest draft version remedies this shortcoming by including Appendix B, which

presents an extended discussion of the topic. FM 7-90 (draft) also points out the inutility of the JMEMs for battlefield use, and has included a set of decision trees for ammunition expenditure guidance, in Appendix B. The various maneuver manuals do not emphasize this topic, in the reasonable expectation that the mortarmen and artillery support personnel will advise maneuver leaders of the capability of their weapons. It is our opinion that the treatment in the new FM 7-90 will provide the guidance that the mortar leaders need to carry out their duties. Such tables not only help in planning a particular fire mission but also help the mortar leader to evaluate his capability to support the commander's intent expressed in the fire plan.

PLATOON LEADERSHIP

The doctrinal manuals make frequent reference to the duties of the mortar platoon leader and his subordinates. In Appendix A, which describes the mortar organizations, the variety of these duties are briefly discussed. In that discussion, a comparison is made between the responsibilities of a mortar platoon leader and his field artillery counterpart, the cannon platoon leader. Both are responsible for the leadership of their platoon and the delivery of indirect fires. However, many differences in operational requirements and the organizational situation exist. We summarize those differences in Table 3.1. Considering the limited specialized training received by lieutenants assigned to become mortar

Table 3.1

Comparison of Mortar and Artillery Platoon Leader Responsibilities

Requirement	Mortar PL	Artillery PL
Imbedded in a command with common training requirements and experience	No	Yes
Expected to independently initiate frequent displacements	Yes	No
Expected to operate in split section	Yes	No
Shares common ammunition and maintenance requirements with parent unit	No	Yes
Expected to select firing positions to support maneuver plan	Yes	No
Expected to participate in fire planning process	Yes	No

platoon leaders, these demands may be unrealistic, and contribute to the disappointing results experienced at the CTCs.

SUMMARY

This review of the doctrinal literature has found that in many cases existing manuals fail to give adequate guidance to maneuver units and mortar leaders. This shortcoming may be responsible for some of the difficulties units training at the CTCs have in making effective use of their mortars. In particular, we found that the maneuver manuals were sometimes vague or inconsistent in specifying preferred modes of employment or missions for mortars in various battle situations. Areas needing emphasis are command relationships and positioning during movement. Closely linked is the topic of assignment of missions for the mortars during battle planning. Doctrine fails to underscore the desirability of making specific arrangements for the mortars. Another serious gap in doctrine is guidance for estimating quantities of fire necessary to accomplish an assigned mission. While fire support doctrine is clear on the circumstances that require adjustment and registration of fires, this guidance is not emphasized in mortar doctrine.

We found that many of these deficiencies are being corrected in draft versions of manuals now being reviewed. In particular, the opportunity exists to improve the mortar situation through revised editions of FM 7-90, FM 7-10, FM 7-20, and FM 71-123 currently in the works.[1] Other recently published manuals may not be revised for some time; thus inconsistencies and deficiencies may not be resolved in the near term.

[1]Although we are informed that FM 71-123 will not be published as doctrine.

4. DATA ANALYSIS

INTRODUCTION

In Table 4.1, we present several hypotheses that provide a focus for this research effort. In order to investigate the issues associated with those hypotheses, we gathered data from a variety of sources, including CTC Take Home Packages, training unit Operations Orders, JRTC Mission Training Plan Performance data, and specially designed field data cards. These cards allowed the Observer/Controllers to answer specific questions about the performance of the mortars and became the primary source of analytical data.

In App. B, we identify the various data sources that were exploited, present several tables that capture mortar performance at each CTC for a sample of battles, and we discuss the contents of the field data cards. We also present several tables that summarize the field card responses by battle phase.

In this section we will interpret the descriptive data presented in App. B by comparing that empirical evidence with the hypotheses in Table 4.1.

GENERAL EMPLOYMENT ISSUES

"Mortars make no contribution; they are ineffective."

This issue is particularly difficult to address and requires a careful differentiation between effectiveness and utilization. A mortar platoon that fires only three missions per battle may be underutilized but may also be very effective. If those three missions prevent an enemy force from breaching an obstacle or screen the movement of a counterattacking force, then the mortars have made a significant contribution and were, in fact, extremely effective. Although our data provide clear evidence concerning the utilization of the mortars, conclusions about the effectiveness of the mortars are not as obvious. We can access the classification system that categorizes fire *missions* as effective (as differentiated from overall effectiveness in battle), suppressive or ineffective. However, this classification scheme varies among CTCs and fails to properly categorize those missions that do not kill but are instrumental to the success of the battle.

Utilization data can, however, provide some insight. Certainly, the platoon that sits idle cannot make a significant contribution to the battle. The platoon that fires only a minimum number of missions is less likely to provide substantial support to the maneuver elements than one that consumes its basic load of ammunition. It should also become clear that underutilization is not the problem with mortars but rather the manifestation of more systemic deficiencies.

Table 4.1

Observations About Mortar Performance from Professional Journals

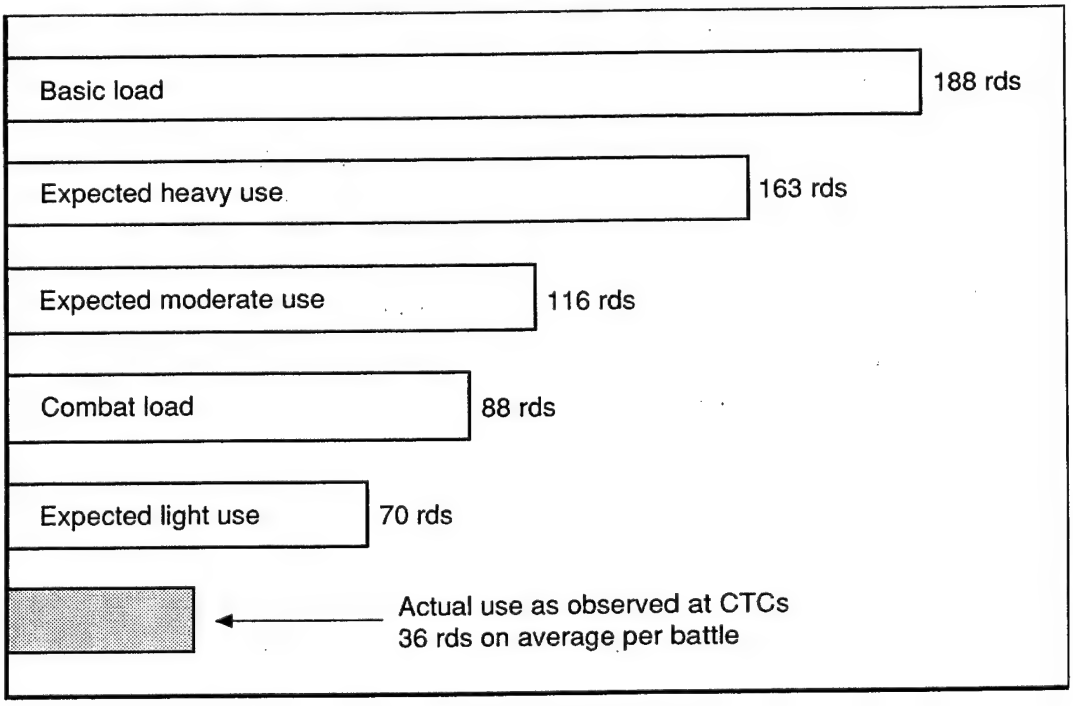
General Employment Issues
Mortars make no contribution; they are not effective.
Communications between the FSO and mortar platoon leader during the battle (are impeded by) limited communications assets.
The effects of mortars are not assessed realistically by the simulation systems used at the CTCs.
Staff responsibilities are not clearly established in doctrine and unit SOPs.
Planning Issues
Mortar platoons do not receive target lists, OPORDs, ACAs, FPFs or priority targets.
Maneuver commanders do not plan final protective fires.
Mortars are not integrated into the fire support plan.
Execution Issues
Company Fire Support Officers do not use mortars.
Fire support teams and forward observers send all missions to the field artillery.
Mortars do not stay within range and are not available when needed.
Mortars are inaccurate; they seldom use surveyed positions and do not apply meteorological corrections.
FSOs do not know which targets mortars are most effective against.
TF FSOs and maneuver S-3s fail to manage mortar ammunition.

SOURCES: "Fire Support Lessons Learned," *Center for Army Lessons Learned Bulletin*, May 1990; "Mortars—Tactical Employment," *Infantry*, September–October 1990.

To measure the contribution of the mortars, we turn to two results that provide some insight about expected utilization. First, FM 101-10-1 provides staff planning data outlining the expected ammunition consumption per tube per day for three levels of combat intensity. Figure 4.1 graphically contrasts these planning figures, the basic and combat loads for a heavy mortar platoon, and demonstrated consumption. We based the comparison on a defensive scenario since a greater consumption of ammunition is expected in defensive

battles, and it has been suggested that mortars are more responsive in defensive scenarios. Figure 4.1 clearly suggests that mortars are underutilized.

Second, a review of MTP mission standards and mortar rates of fire indicate that the heavy mortar platoon can consume its basic load in less than one hour. This assumes that all missions are fired within MTP published standards, that there is no down time between missions, and that the platoon enters the battle with a full combat load. If only "fire-for-effect" missions are fired, the time to expend the entire combat load is approximately 49 minutes. If "adjust fire" missions are conducted, then the expected time is 56 minutes. In either case, if the target is an armored vehicle requiring 54 rounds in effect, the platoon will fire between 9 and 10 missions. THP data, displayed in Table 4.2, clearly indicates that the mortars, on average, fall far short of this mission count even though the time and targets are probably available in force-on-force battles.



NOTE: Expected usage is derived from FM 101-10-1.

Fig. 4.1—Actual vs. Doctrinal Ammunition Consumption Levels

Table 4.2

Average Mission Count & Ammuntion Consumption Level per Battle

CTC & Caliber	NTC 107mm	CMTC 107mm	JRTC 81mm
Number of battles	62	32	42
Missions per battle	5	7	12
Rounds per platoon	199	139	134

"Communications between the FSO and the mortar platoon leader during the battle (are impeded by) limited communications assets."

While the data cannot directly refute or support this hypothesis, they do indicate that if valid, the impact of this hypothesis is marginal.

First, if we review the number of missions for which the mortars were specified but were unable to fire, communications problems account for only 6 of 190 failures or less than 3 percent. Second, in over 85 percent of the battles the mortar leadership was monitoring some net, either the Task Force command net or the company command net, which is also monitored by the FSO and which provided a possible communication link. Communications assets never surfaced as a problem during any observer debriefings.

Ironically, there is a very interesting issue suggested by this hypothesis for which we did not gather any data. Through discussions with player units and O/Cs and a review of THPs and professional journals, it has become clear that almost all units create a Task Force voice fire coordination net over which the TF FSO, company FIST, platoon FOs, and the mortar platoon leader can discuss a variety of fire support coordination issues. In addition, several THPs recommend that the TF FSO create a communications structure that would allow him to monitor calls for fire. Specifically, the THPs recommend that the FISTs call the FSO on the Task Force voice fire support coordination net to clear the mission before submitting the mission digitally on the appropriate fire direction net.

Doctrine is far from consistent in its treatment of this important voice fire support coordination net. Several Field Artillery manuals, including FM 6-20-40 and FM 6-20-1, identify the net and indicate that the Task Force fire support cell should be the net control station. On the other hand, the primary maneuver documents for mortar employment, including FM 71-2 and FM 7-90, do not identify such a net. FM 71-2 identifies both the primary and special radio nets for the Task Force but does not list the fire support coordination net in either category. However, it does mention a "Task Force fire support net" later in the text. FM 7-90 lists those nets that the mortar leadership can expect to operate in and never mentions the voice fire support coordination net. Currently fielded CEOIs

(Communications-Electronic Operating Instructions) do not authorize a net to the Task Force to be used as a voice fire support coordination net.

Units routinely work around this problem by "commandeering" one of the two mortar digital fire direction nets and utilizing that net as the voice fire support coordination net. Although this appears to be a satisfactory solution, it is certainly not supported consistently by doctrine. It may have some impact on the operation of the mortar platoon particularly when the platoon attempts to deploy in section configuration and no longer has the second digital net to support independent section operations.

"The effects of mortars are not assessed realistically by the simulation systems used at the CTCs."

The issue addressed by this hypothesis is discussed in great detail in Sec. 2. As a matter of review, the reader will recall that suppressive effects are not simulated realistically at the CTCs, that the ground rules for assessing mortar performance at the CTCs are not standardized, and that the lethality guidelines are quite generous for the mortars.

Any assessment of heavy mortar employment at the CTCs must be tempered with an understanding of infantry operations at those training centers. One of the primary missions of mortars is to support the dismounted infantry battle, but our data indicate that at the NTC and CMTC dismounted infantry activity was not routinely planned in every battle and, surprisingly, the assignment of infantry support missions to the mortars was even less frequent. In fact, at the NTC, dismounted infantry activity was planned in 70 percent of the battles while at the CMTC, dismounted infantry was planned in only 60 percent of the battles. This was especially surprising since one motivation for extending this study to the CMTC was based on the argument that the terrain at that training center is more favorable to infantry operations and should, therefore, encourage greater mortar use. A more dramatic difference is noted in the frequency with which mortars are linked to the dismounted infantry mission. At the NTC, mortars were linked to the infantry plan in 93 percent of the cases while at the CMTC, this linkage was developed in only 36 percent of the cases.

"Staff responsibilities for mortars are not clearly established in doctrine and SOPs."

This again is an issue we have addressed in the doctrinal review. Our conclusion remains, however, that the responsibility for integrating the mortars into the fire support plan and the maneuver plan is clearly the responsibility of the TF FSO and the TF Commander.

PLANNING ISSUES

"Mortar platoons do not receive target lists, OPORDs, ACAs, FPFs, or priority targets."

The first supposition in this cluster suggests that the mortars are not receiving the information necessary to execute the assigned mission. As detailed in Table 4.3, the data contradict this hypothesis. In the case of the heavy mortars, the platoon leadership is usually privy to all plans, routinely participates in briefings and, with some consistency, understands the commander's concept. Whereas the leadership in the medium and light organizations demonstrate a significantly lower level of participation in task force or company level planning, they are usually briefed and seem to comprehend the commander's intent.

"Maneuver commanders do not plan final protective fires."
"Mortars are not integrated into the fire support plan."

These hypotheses strike a key issue. Since mortars seem to have access to the fire plans, it is appropriate to question how well those plans integrate the mortars and create the preconditions for optimal employment. Certainly, if there is no effective plan to use the mortars, then we should not be surprised by results that indicate a lack of utilization.

One indicator of this integration is the assignment of Final Protective Fires (FPFs) to the mortars. FM 7-90 (draft) encourages this assignment and argues that it "frees artillery to attack and destroy follow-on echelons." The data, however, indicate that commanders do not seem to exploit this capability of the mortars. Heavy platoons deployed at the NTC and CMTC demonstrated responsibility for an FPF by either adjusting or actually firing such a mission in only 5 of 32 defensive engagements. Similarly, disappointing results are noted for the medium and light mortars. Medium mortar platoons adjusted or fired an FPF in only 2 of 13 defensive battles while light mortar sections were assigned an FPF in only 2 of 30 defensive operations.

Table 4.3

Mortar Planning Issues

Percent of time that:	NTC 107mm	CMTC 107mm	NTC 81mm	JRTC 81mm	NTC 60mm	JRTC 60mm
Platoon/section has fire plan	97	90	100	18	44	50
PL/SL participates in:						
TF/Company planning	81	88	55	36	49	46
TF/Company briefing	100	95	95	73	84	93
PL/SL understands commanders' intent	84	98	91	73	87	79

NOTE: PL = Platoon leader; SL = Section leader.

The data further indicate that the mortars are being ignored as a source of smoke and illumination support, with smoke missions comprising less than 8 percent of the missions fired and illumination missions comprising less than 5 percent of the total mission count. We cannot argue that commanders do not consider the assignment of FPFs and the need for smoke or illumination. They may, in fact, be heavily exploiting the capability of all available Field Artillery assets. However, the data suggest that commanders may be ignoring a valuable asset by allowing the mortars to sit idle at those moments in the battle when they could provide critical support.

The assignment of doctrinal missions is only one indicator of mortar integration into the fire support plan. Several additional questions on the field data cards address this issue. Based on the significance of this issue, we reexamined the THPs to derive additional information. The THP information, as well as the responses to the questions on the field data cards for the heavy mortar platoons, is tabulated in Table 4.4.

The O/Cs are only marginally optimistic in their subjective assessment of mortar integration into the fire support plan, and this assessment is supported by the responses to the more specific questions. Certainly, if the heavy mortars training at the CMTC are assigned specific targets in only 59 percent of the battles observed and in only 26 percent of that subset were observers tasked to trigger the mortars' fires, then there is good reason to suspect a marginal level of integration. The data from the THPs provide even more disappointing evidence. Mortars should not be considered integrated into the fire plan if, in 88 percent of battles observed, they are not assigned responsibility for any targets.

Table 4.4

Mortar Integration Issues

Field Data	NTC 107mm	CMTC 107mm
Were mortars integrated into		
maneuver plan?	64	41
fire support plan?	69	62
Were mortars assigned specific targets?	NQ	59
If so, were observers linked to mortar targets?	—	26
Is there a fire support rehearsal?*	85	79
If so, did the mortars participate?	33	23
THP Data		
FA targets planned per battle	89	33
Mortar targets planned per battle	0.7	0.5
% of battles in which 0 mortar targets are planned	66	88

NOTE: Question responses are expressed in percent.
NQ = not included in cards fielded at the NTC.
* = NTC data based on THP review.

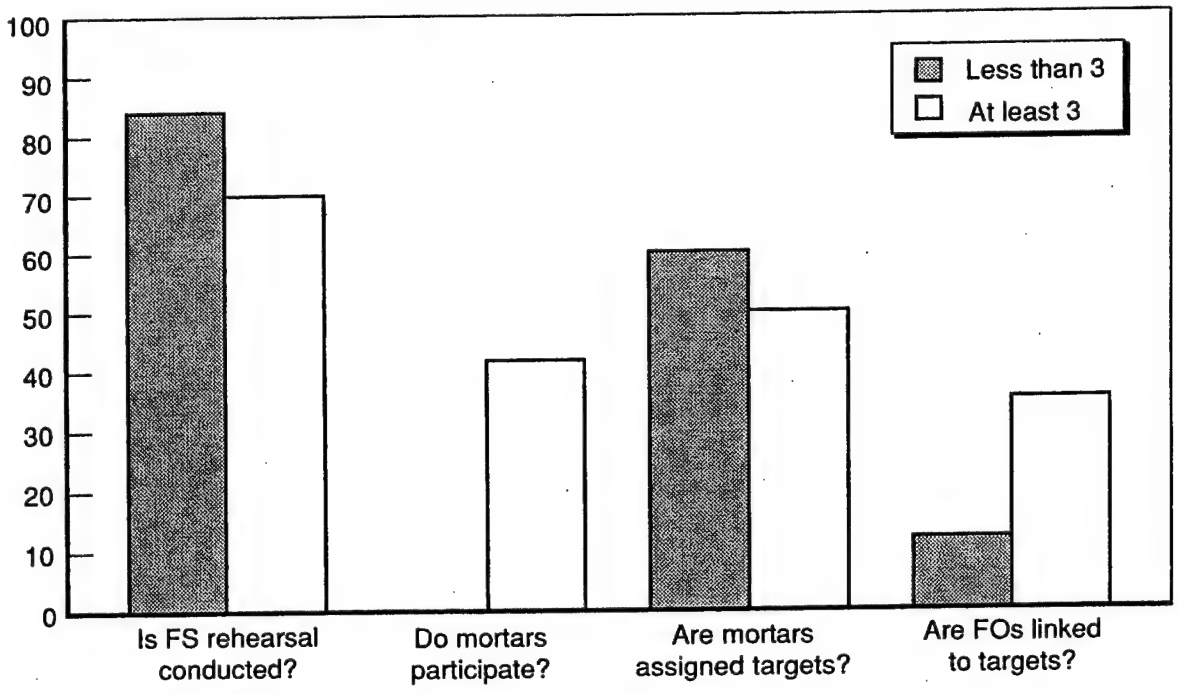
A comment frequently heard is that participation of the mortars in the fire support rehearsal is an excellent barometer of their integration level in the fire support plan. If the mortars have no responsibility for any targets, then there is probably little to rehearse and less motivation to attend the fire support rehearsal. The data show that the mortars attend less than 34 percent of the fire support rehearsals. Unfortunately, this absence generates additional impediments to mortar utilization, not the least of which is a mindset among observers that the Field Artillery is the only available source of indirect fire support and that the mortars are, at best, a weapon of last resort.

If participation in fire support rehearsals and other measures can be viewed as indicators of the level of integration in the fire support plan, then it would be interesting to examine the relationship between these indicators and the number of fire missions conducted during the course of a battle. One hypothesis might argue that a higher level of integration should result in a greater number of missions fired. An alternative hypothesis is that a quality fire plan may require the mortars to fire only a limited number of missions, but those missions are in support of a critical task; our data cannot address this argument.

We use the data collected at CMTC to examine the first hypothesis. Considering that three missions on average were fired by the mortars during a battle, we compare the response rate for the various planning indicators between those battles with at least the average number of missions and those battles with less than the average number of missions. The results, depicted in Fig. 4.2, are quite revealing. In both categories, Fire Support rehearsals are conducted and mortars are assigned specific targets with similar frequency. However, for the "below-average" battles, the mortars never attend the fire support rehearsal. Consequently, even in those infrequent cases in which the FOs are "linked" to fire the mortar targets, those links are not rehearsed and may be of questionable effectiveness.

A similar analysis of the data generated at the NTC was conducted. This review identified one platoon that consistently surpassed all other training units both in terms of the average number of missions fired and the number of rounds fired per battle. This information, as well as the response rate for critical planning measures, is listed in Table 4.5.

Several observations about this unit are quite interesting and enlightening. First, as the data show, the platoon leadership was consistently involved in task force level planning. Second, the platoon always operated in a platoon configuration under Task Force control with a priority of fire mission. Though we do not argue that this should be accepted as the optimal deployment option, we suspect that this standard operating technique may have relieved the platoon of certain planning requirements and might have enhanced battle preparation. Finally, as the data show, the platoon conducted a rehearsal in three of its six



NOTE: Value axis represents percentage of time an event occurs.

Fig. 4.2—Comparison of Mortar Platoons at CMTC Based on Number of Missions Fired per Battle

Table 4.5

Mortar Platoon Comparison at NTC

	All Others	Outlier
Average number of rounds fired per battle	182	445
Average number of missions per battle	4	10
Is PL involved in Task Force planning?	79	100
Is PL at Task Force rehearsal?	85	100
Is platoon integrated into Task Force fire plan?	65	100
Does PL understand Commander's concept?	83	100
Does mortar platoon conduct rehearsal?	43	50

NOTE: Question responses are expressed in percent.

rotational battles. The three rehearsals were conducted with the FIST teams from the task force. These internal rehearsals may have served as surrogate fire support rehearsals and the results achieved, as displayed in Fig. 4.3, are quite remarkable. Figure 4.3 clearly

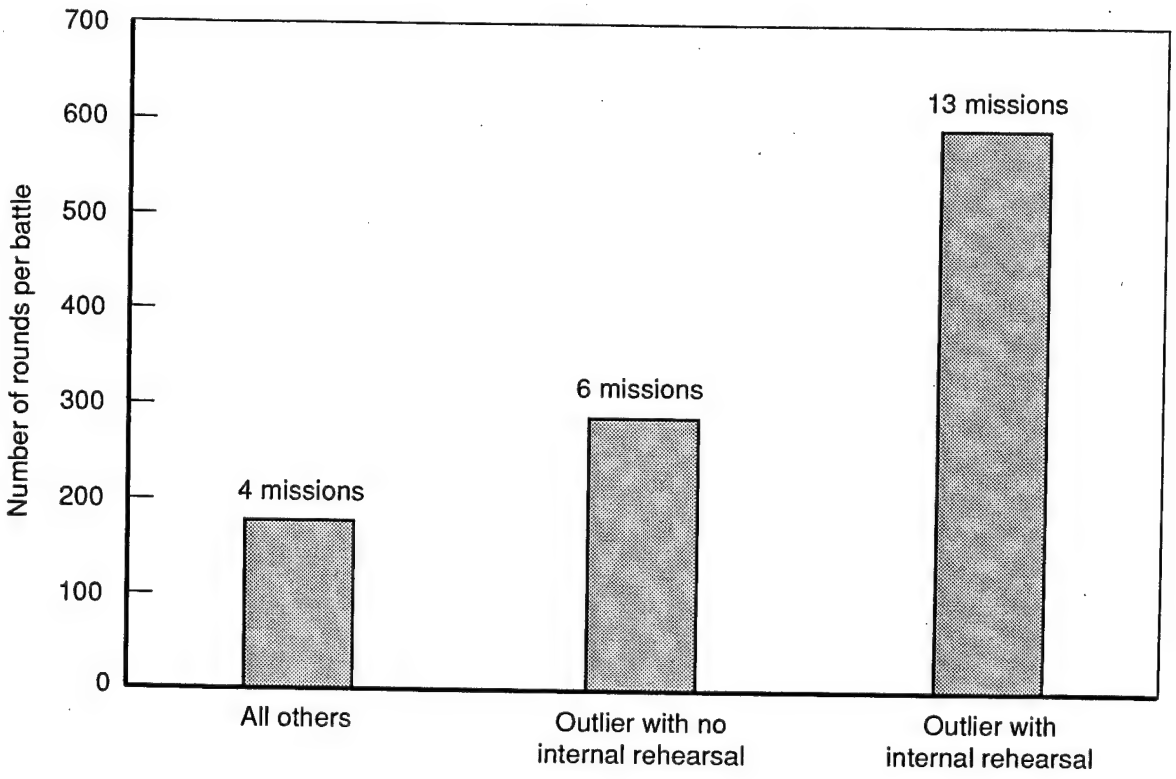


Fig. 4.3—Performance Comparison of "Outlier" Platoon to All Others at NTC

illustrates the increase in average number of rounds fired per battle and the associated increasing average number of missions. Those battles in which an internal fire support rehearsal was conducted represent the only battles in our data set in which a platoon consumed its combat load.

We cannot conclude that there is a clear causal relationship between the conduct of planning activities and the number of missions fired. The data argue, however, that some link exists between the preparation of an integrated fire plan, the rehearsal of that plan, and the number of missions fired.

EXECUTION ISSUES

"Company fire support officers do not use mortars."
"Fire support teams and forward observers send all missions to the field artillery."

These assumptions are, in fact, parallel arguments. Based on the review of planning issues, we recognize that if the mortars are not integrated into the fire support plan and do not attend the fire support rehearsal, then there may be a predilection among observers to ignore the mortars as a source of fire support and to send all missions to the available Field Artillery assets.

The data provide some support for these hypotheses. First, the O/Cs at CMTC were asked to track the number of missions fired by Field Artillery units during the course of a battle and to determine how many of those missions could have been diverted to a mortar platoon that was capable of responding to the request for support. They reported that, on average, 21 percent of the missions fired by Field Artillery units could have been handled by the mortars. Second, as data presented in Table 4.4 indicate, mortars are very seldom assigned any preplanned targets and can only expect to attack targets of opportunity. However, a review of NTC THPs indicates that, in addition to almost all the preplanned targets, approximately 83 percent of the targets of opportunity identified during force-on-force battles and 86 percent of the targets of opportunity identified during live fire battles are sent to the Field Artillery. For 10 of the 59 battles in this data set, the mortars sat idle. In these very same battles, the Field Artillery units fired more than their average number of missions. Although there is no doctrinal criterion for the proper mix of missions for each system, the data clearly suggest that the preponderance of missions are being transmitted to the Field Artillery, even when the mortars could respond and provide the requested support.

"Mortars do not stay within range and are not available when needed."

The responsiveness of the mortars is at the heart of this issue. The comparative speed and mobility of the M106A1 carrier is often cited as a limitation, and it is suggested that the mortars will often find themselves outdistanced by maneuver units equipped with modern equipment. Our data, however, suggest that this is not a limitation and that the mortars remain quite responsive throughout the course of most battles. As illustrated in Fig. 4.4, mortars are quite responsive. Our data indicate that, on average, mortars fire 82 percent of the missions called.

We had anticipated that the three stated constraints would limit the responsiveness of the mortars as shown in Table 4.6. While these factors certainly did have some impact, none of them surfaced as the sole or primary contributing factors. In fact, it was a plethora of *other* issues that often precluded the mortars from firing. These other issues included:

- The platoon was under NBC attack and simply did not fire the missions
- The platoon's FDCs were destroyed and there was no back-up data computation capability
- The FDCs were asleep and simply did not answer the calls for fire
- Attack guidance precluded mortars from firing on a certain class of target that was included in the target description of the call for fire.

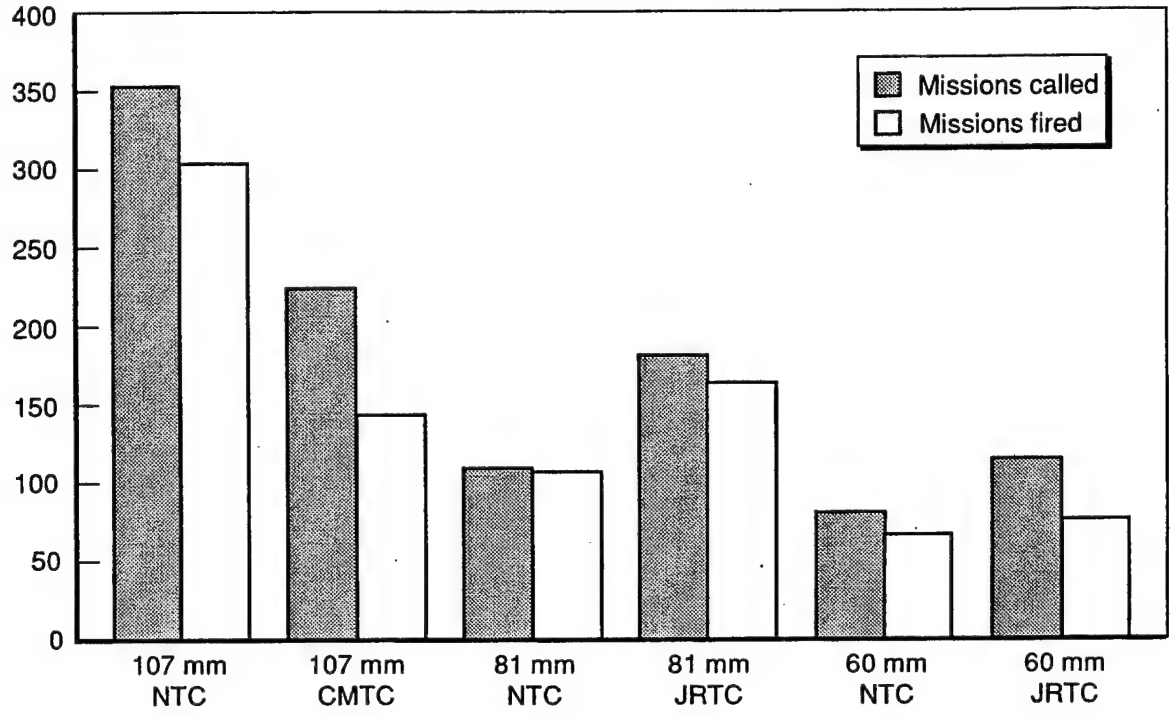


Fig. 4.4—Comparison of Missions Called to Missions Fired by Caliber Weapon and CTC

Table 4.6

Mortar Execution Issues

	NTC 107mm	CMTC 107mm	NTC 81mm	JRTC 81mm	NTC 60mm	JRTC 60mm
Missions called	354	219	105	175	77	110
Missions fired	305	141	103	160	67	74
Reason mission not fired:						
Mortars out of range	41	13	0	7	6	1
Mortars out of ammo	3	10	1	1	1	0
Communications problems	0	2	0	1	0	3
Other	5	53	1	6	3	32

There are two additional points for consideration. First, the primary data employed in support of this report are based on force-on-force exercises wherein there is no prohibition against mortars firing over the heads of friendly soldiers, and mortars are unconstrained in

the selection of firing positions. This prohibition is in effect in live fire exercises and may reduce responsiveness as the mortars attempt to maneuver to flank positions from which they can fire. Second, based on observed fire mission load, the mortars are certainly not stressed or subject to overload. However, if the mortars were asked to fire a more demanding and perhaps more realistic number of fire missions, we might observe a decline in responsiveness.

"Mortars are inaccurate; they seldom use surveyed positions and do not apply meteorological corrections."

As we reported in an earlier section, rounds fired during an indirect fire mission in force-on-force battles are presumed to impact at the location designated by the forward observer in the call for fire. Hence, we have no data that directly address the issue of mortar accuracy. However, we also recognize that there are several conditions that must be satisfied in order for mortar fire to be accurate.

First, the unit must have confidence in its ability to accurately compute firing data. Our data indicate that the mortar ballistic computer has a 99 percent availability rate and adequately supports this requirement. Second, the unit must have current MET data. We did not specifically list this issue as a point of investigation on the field data cards; however, in post-rotational outbriefings O/Cs would usually report that mortar platoons typically do not receive any MET messages. This is not surprising in light of the translation exercise required to make a computer MET useable for the mortars. In addition, a review of JRTC Performance Data for a series of 32 battles indicates that in only 2 battles did the unit receive a "go" rating for computing MET corrections. Third, the target must be located accurately. A previous RAND study using U.S. Army data [1] indicates that an unaided observer, operating without the benefit of a laser range finder (as is the case in force-on-force exercises), experiences an average target location error of 400–500 meters. As we have discussed, the mortars primarily attack targets of opportunity, and our data show that 85 percent of such targets are identified by grid location rather than by reference to a predetermined location or TRP. Hence, the target locations are certainly susceptible to the expected location error. Fourth, the firing position must be located accurately. The same RAND report includes Army data, which show that unaided self-location typically introduces a mean error of approximately 200 meters. Table 4.7 identifies the frequency with which mortar elements receive survey support or must rely on other techniques (map-spot or hasty survey) to identify the location of their firing position. Clearly, mortars seldom satisfy the requirement for accurate firing position location. Finally, the last ingredient for accurate fire

is the presence of current registration data. Table 4.7 shows that of the 850 mortar missions fired during the course of this study, only 4 were registrations.[1]

Doctrine clearly suggests that if any of these conditions cannot be satisfied, then the unit should *adjust fire* as opposed to attempting to *fire for effect*. Based on the data presented, we would expect to see a majority of adjust fire missions conducted by the mortars. Surprisingly, only 13 percent (111 missions) of the missions observed are adjust fire missions with 90 of those missions occurring at the JRTC. We are unable to fully explain the observed differences between the CTCs; however, we suspect that the nature of the targets at the JRTC and some O/C level coaching may be encouraging the conduct of adjust fire missions.

It must be reemphasized that our data cannot predict the accuracy of the mortars in a live-fire scenario. In fact, if mortars satisfy the conditions outlined, they should be as accurate as any other fielded indirect fire system. However, our data indicate that mortar elements are not exploiting the available training opportunity to practice those very activities that will be required to achieve accurate fires.

"FSOs do not know which targets mortars are most effective against."

Current doctrine argues that mortars are "very effective against lightly protected personnel and for obscuration, illumination, suppression, and close-in defensive fires" (TC 6-71, p. 8), and we must assume that all FSOs know these doctrinal recommendations. It is interesting, therefore, to compare the nature of the missions routinely conducted by the

Table 4.7

Mortar Accuracy Issues

	NTC 107mm	CMTC 107mm	NTC 81mm	JRTC 81mm	NTC 60mm	JRTC 60mm
Missions fired	305	141	103	160	67	74
Registrations	1	0	0	0	1	2
Adjust fire missions	5	11	0	60	5	30
Percent of positions located by						
Map-spot	70	98	59	91	No Data	
Hasty-survey	24	2	0	0		
PADS	6	0	41	9		

[1]This is a point of some contention as player units and, in fact, some O/Cs report that it is simply too hard to conduct the necessary coordination to have firemarkers in place to simulate the conduct of a registration. The NTC Werewolf Team, which controls the firemarkers in the field, argue strongly, however, that firemarkers are available as needed to support any mission which the unit may desire to initiate.

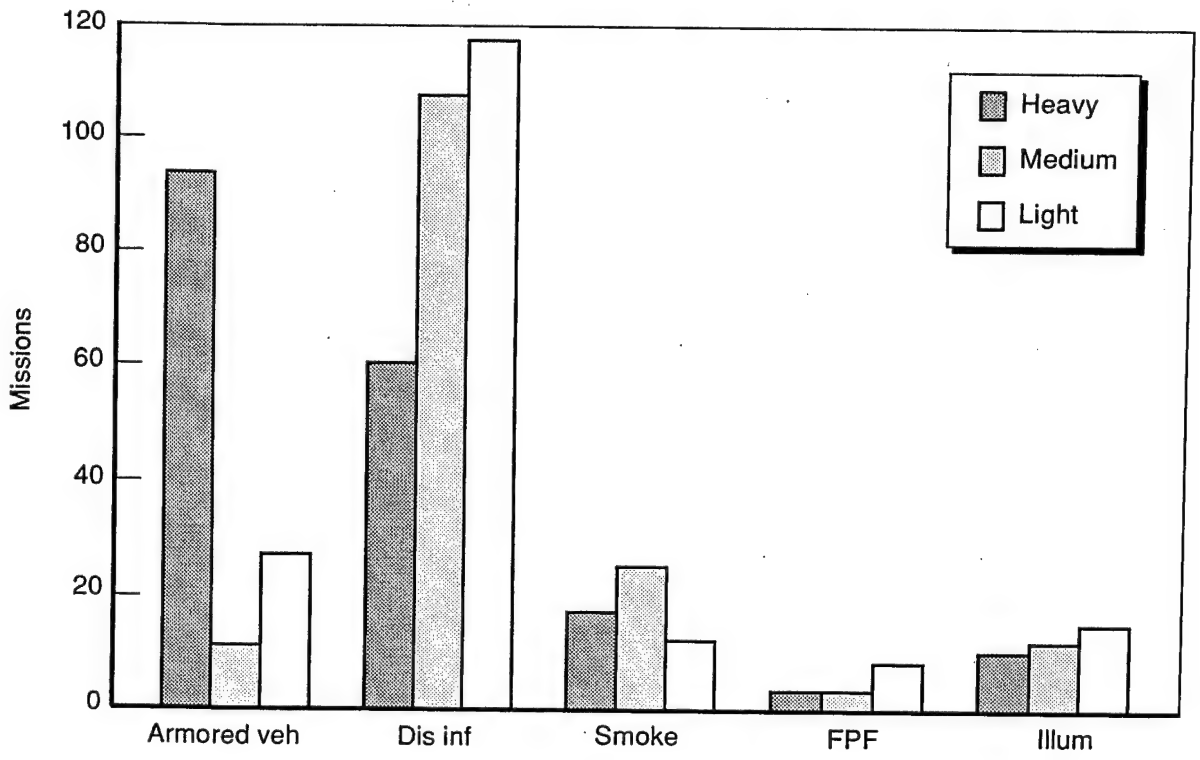


Fig. 4.5—Number of Fire Missions by Mortar Type

mortars with these doctrinal expectations. A distribution of the mission types conducted by the mortars is illustrated in Fig. 4.5.

The paucity of FPF missions has already been addressed and may be linked to a failure to fully integrate the mortars into the fire support plan. A similar argument holds for the lack of smoke and illumination missions. Several sources have recommended that the mission of providing illumination support should be the sole responsibility of the mortars thereby freeing the Field Artillery to attack targets identified under the illumination. However, as with FPF missions, this requires that the mortars be clearly integrated into a fire support plan that synchronizes the field artillery and the mortars and links observers to the mortars to initiate the appropriate missions.

The propensity of the heavy mortars to attack armored vehicles requires additional investigation. This tendency may reflect the nature of the target array that is portrayed to the training unit. There is no evidence that the mortars are denying support for other missions while they attack these targets and the mortars might sit idle if they did not attack these targets. Unfortunately, the heavy platoons fired only an average of 36 rounds in effect

in these missions which, according to the ROE, is insufficient to destroy such targets. As a result, the mortars can only suppress the targets, and this has limited impact on the course of the training battle. Again, with proper integration into the fire support plan, a more optimal distribution of fires might have the heavy mortars providing illumination and smoke support, and concentrating on dismounted infantry targets, to include FPFs.

The medium and light mortar elements appear somewhat more conventional in their target selection. Even the light elements training at the NTC seem to concentrate on dismounted infantry targets. Of course, this probably reflects the nature of the light unit mission. However, even these elements are infrequently tasked to provide illumination or smoke support.

"TF FSOs and maneuver S-3s fail to manage mortar ammunition."

For most weapon systems, maintaining the necessary stocks of ammunition is a demanding task requiring the coordinated efforts of both operations personnel and logistic planners. This hypothesis suggests that the management of mortar ammunition is no exception. However, this challenge is normally created by the high demand that most systems impose on the supply system, a high demand noticeably absent in the case of the mortars. In fact, as Fig. 4.6 illustrates, all caliber mortars consume, on average, less than 30 percent of their issued load, and the requirement to manage mortar ammunition is not a critical task.

Further, the data indicate that task force and company staff do not ignore ammunition planning. First, the O/Cs report that in a majority of battles a plan for Class V resupply is generated. In fact, for the heavy platoons such a plan exists in approximately 72 percent of the battles observed, whereas the medium platoons have a plan in 75 percent of the battles. Planning for resupply of the light mortars occurs much less frequently, with a plan developed in only 38 percent of the battles. Second, in approximately 50 percent of the battles, the O/Cs reported that the medium platoons did receive ammunition resupply. Similar data were not collected for either the heavy or light mortar elements. Finally, as indicated earlier, only a few of those missions received but not fired were due to a lack of ammunition. This may simply reflect the underutilization of the mortars but also argues that some resupply occurred during the course of the rotation.

Some O/Cs suggest that the composition of the ammunition load should vary with the battle type anticipated and the expected mission of the mortars. In light of the minimal integration of the mortars into the fire support plan, it is not surprising that we observed minimal variation in the ammunition load issued to the mortars throughout all battles; and

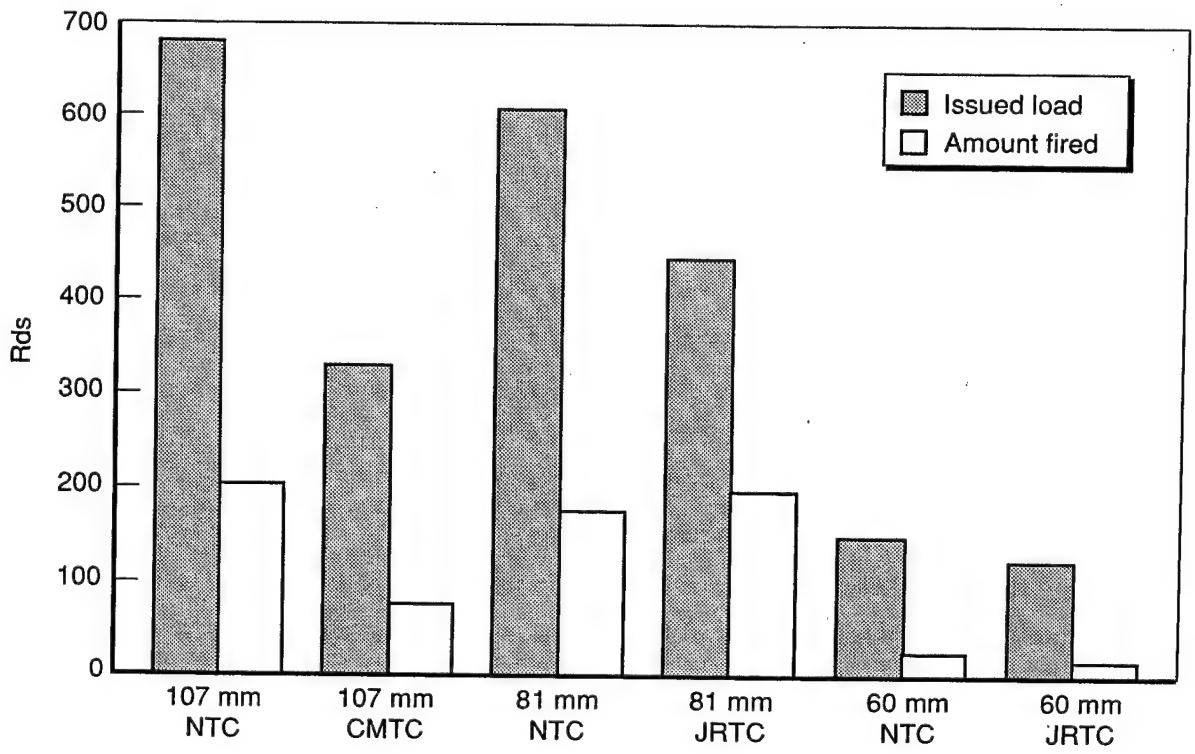


Fig. 4.6—Ammunition Consumption vs. Issued Load by CTC and Caliber Mortar

that the mortar platoons routinely deployed with a mix of approximately 66 percent HE, 24 percent WP, and 10 percent Illumination.

It is quite interesting to note that the mortars routinely consume a small percentage of their combat load, yet frequently fail to fire enough ammunition to destroy a particular target. Some argue that the platoon leadership is husbanding rounds based on an anticipated lack of resupply; others argue that this dichotomy is caused by a failure to understand the published ROE and the lack of a doctrinal source that outlines attack guidance by target type. While the data cannot explain this phenomenon, it is clear that the limited number of missions fired and the relatively low rate of fire per mission have eliminated mortar ammunition management as a critical concern for the task force and company staff.

5. CONCLUSIONS

This study of mortar utilization has endeavored to answer three separate questions: Are the CTCs a proper test of mortar utilization? Are mortars underutilized at the Combat Training Centers? If both questions are answered in the affirmative, can the causes of underutilization be identified? A corollary from the last question is whether fixes can be identified to improve the situation. The study provided positive answers to all of the above.

CAN MORTARS BE EVALUATED AT THE CTCs?

The first major question is whether the CTCs provide a valid venue to examine mortar operations. We conclude that the CTCs offer an adequate training experience in the tactical employment of mortars. Our examination indicates that the greatest impediment to accurate replication of all caliber of mortar operations is the virtual absence of suppression caused by indirect fires (or other area fire suppressive weapons). In many cases, even proper application of mortar fires might fail to yield the results that would be seen on the actual battlefield. On the other hand, smoke effects, illumination, and lethal fires are replicated by firemarkers and the rules of engagement (ROE).

The most substantial drawback for heavy mortar training is the limited dismounted infantry activity observed at the NTC and CMTC; for it is during such events that the mortars should see their greatest use.

The accuracy of mortar fires is generally overstated during force-on-force engagements at the CTCs. Until recently, the impact area of a mortar mission was greatly exaggerated at the NTC. This is no longer the case there, but the scoring systems differ at each of the CTCs. In general, it must be recognized that the only element of mortar accuracy measured at the CTCs is the accuracy of the original call for fire; the shells are assumed to land at the grid location of the fire call. Effects of firing location error, sight misalignment, meteorology, and so forth are incompletely considered.

The data from this study clearly indicate the need to register or adjust mortar fires to achieve consistent effectiveness. We also have shown that adjustment is seldom practiced, particularly by the heavy mortars. Some observers have claimed that the CTC firemarking system will not support the technique of adjustment or registration. Our review of the practices at the CTCs indicates that this is an incorrect claim; thus we do not regard the fire-marking systems as a deficiency sufficient to prevent proper mortar training at the CTCs.

ARE MORTARS UNDERUTILIZED?

There is little doubt remaining that mortars are underutilized at the CTCs, although levels of utilization vary at each of the locations. The largest data set generated in the study came from heavy mortar operations at the NTC and to a lesser extent at the CMTC. It is also true that the researchers were able to become most familiar with heavy battalion operations, as contrasted to light battalion operations at the NTC and the JRTC. Thus the majority of our conclusions are most pertinent to heavy mortar employment. Most of the conclusions will also apply to medium mortars. Our grasp of light mortar operations is considerably less, and clearly many of our conclusions do not apply to them.

There is no absolute standard for mortar utilization against which we can measure battle results at the CTCs. Therefore one could argue that the data do not prove that the mortars are underutilized. However, the numerical data clearly show that the mortar platoons do not consume ammunition at rates suggested by doctrine, that in many cases they do not fire sufficient rounds to bring about desired effects, that they are not commonly utilized for the missions suggested by doctrine, and that they have a very low rate of success in striking targets. Further, qualitative data revealed by THP review indicate that the mortars are seldom credited with having an important effect on battle outcome.

CAUSES OF UNDERUTILIZATION

We have been able to identify a number of factors that influence the utilization of mortars. These factors are interconnected in many cases, and we have found it convenient to use Fig. 5.1 to illustrate the problems we have uncovered. Beginning at the left-hand box, we list limited infantry play and inadequate replication of suppression. Proceeding clockwise, these factors lead the task force commanders and staff to place little value on the mortar contribution; thus they devote little attention to planning for mortar use. The consequence of this effect is that the mortars are not integrated into the fire plan and often are not included in rehearsal. Even classic mortar missions are often assigned to the artillery. The consequences of this situation appear in the bottom box, which states that the mortars fire a limited number of missions with limited effect. To bring about an improvement in mortar utilization, this loop must be broken. To assure the robustness of the "break," it would be advisable to break the loop in several places. Our research has revealed possibilities for breaking the loop through improvements in equipment, doctrine, training, leadership, and organization. The possibilities are summarized in the following sections.

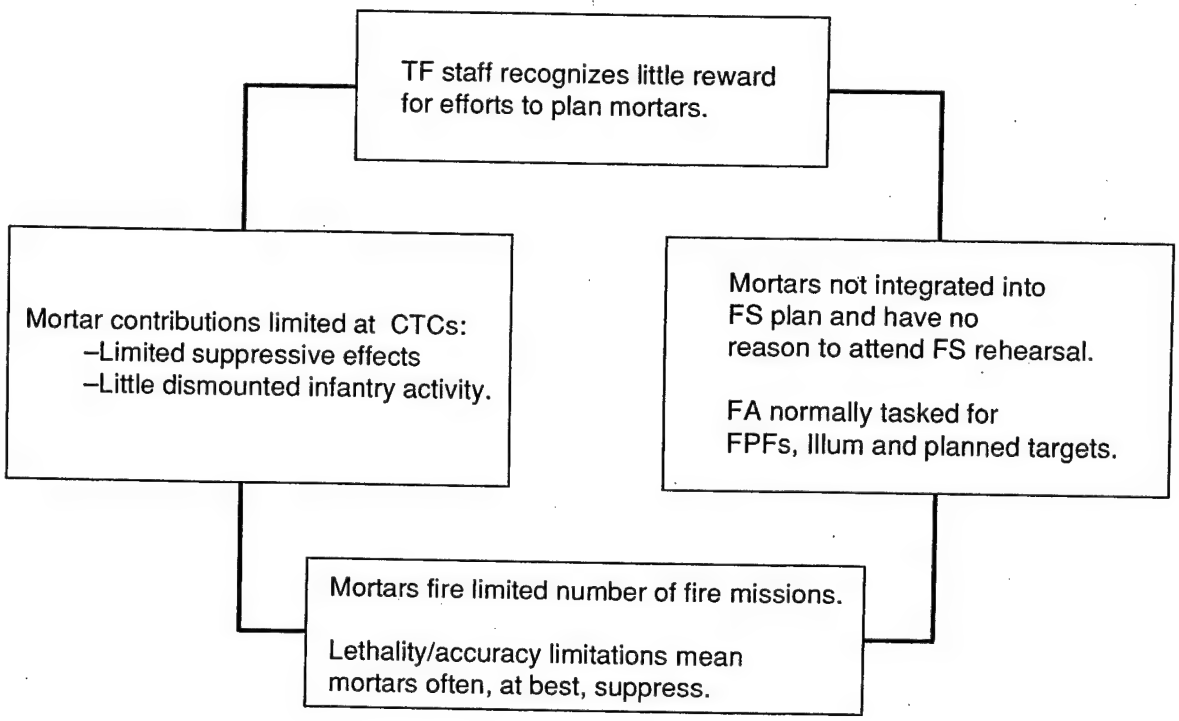


Fig. 5.1—Mortar Training Loop

EQUIPMENT

When articles or columns are written concerning improvements expected in the armed forces, the future is often cast in terms of new equipment. This is also true of mortars. For example, the Army intends to replace some or all of the heavy mortars with a 120mm smooth-bore tube having improved lethality and operating characteristics. Advanced munitions are being considered that offer greater effects against armor targets or other advantages. But as our data have shown, the present problems with mortar employment are not equipment-centered. The present mortar computer is quite reliable, for example, and would benefit from a capability of interfacing with the TACFIRE system or its follow-on. In particular, the ability to accept computer meteorological messages would improve mortar operability and accuracy. Better firing position location offered by devices such as the global positioning satellite, which proved its worth repeatedly in Operation Desert Storm, will eliminate another source of error, eliminate navigational problems, and obviate the need for trying to arrange for PADS support of mortar operations. We remind the reader, however, that the present problems uncovered in mortar operations do not have their roots in these equipments. Historically, in war, mortars have proven their effectiveness operating in manual modes and utilizing registration and adjustment to achieve accuracy.

Artillery, which strives for first round fire for effect, suffers in the CTC environment from the inability to use the laser capability of the G/VLLD, for safety reasons. The mortars, which usually cannot achieve first round accuracy owing to the meteorology and positioning problems mentioned, should suffer less from this target location problem, as adjustment is a necessary procedure in any case. However, the mortars would still benefit from having the eye-safe HGSS training simulator available to the training units. We must remember, however, that platoon forward observers, who traditionally have called many of the mortar fires, are not equipped with G/VLLD and in the heavy forces are not even equipped with hand-held laser rangefinders. In summary, the new equipment on the horizon for mortars may allow them to deliver unadjusted first round fire for effect. However, the present inability to do so does not account for the relative ineffectiveness of the mortars as seen at the CTCs. Means should be taken to increase the current effectiveness of the mortars before new equipment is added to the force.

Some observers have questioned the adequacy of ammunition haul capacity to support the heavy and medium mortars. As our data show, this is not currently a problem. If other measures are taken to improve mortar effectiveness, with the consequence that units place greater demands on the mortar system, haul capacity could become a limiting factor.

DOCTRINE

We believe that some extensions and clarifications of doctrine would be beneficial. Our recommendations can be divided into two categories—those of primary concern for the call and delivery of fires, and those pertinent to the integration of mortars into the combined arms.

Call and Delivery of Fires

In the first category we found that advice on lethality of mortar munitions is inadequate in existing field manuals. Simple tables suggesting the necessary round count to accomplish common missions would give needed guidance to mortarmen and fire support personnel. An important point for both the fire support manuals and the mortar manuals is the necessity to register or adjust mortar fires to assure adequate effects on targets. The very low fraction of mortar missions that are judged by CTC personnel to have been effective stresses the importance of this point.

While units work around the ambiguity of radio net assignments for the mortars, it would be worthwhile to achieve commonality among manuals and clearly identify the battalion fire direction net and provide it with frequencies in the CEOI.

Mortar units lack success in developing productive techniques of rehearsal, yet we found that rehearsal and success were clearly correlated. Rounding out suggestions for the mortar manuals is the thought that examples of useful rehearsal techniques may lead units to more successful practices in this regard.

Integration of Mortars

The second class of doctrine is that which establishes recommended applications for the mortars and guidance for maneuver commanders and fire planners. Here our major finding is not that the doctrine is incorrect or incomplete. The point most astonishing to us is how seldom doctrinal guidance is followed by the training units. We have shown the small fraction of mortar missions devoted to the classic tasks of smoke, illumination, and final protective fire. We have also noted how seldom the mortars are closely linked to one of the maneuver sub-units (companies) for a particular mission. The result seems to be that fire missions are generally passed to the field artillery, thus overworking that asset while leaving the mortars idle. This is a synchronization problem because it typically results in a failure to produce maximum combat power at the decisive point of the battle. The use of an execution matrix that has been shown effective in many other contexts will have beneficial results. Examples of possible matrix formats have been included in recent professional journals; the inclusion of a recommended format in doctrine may focus attention on the mortar planning process, and a few well chosen examples may underline important doctrinal guidance.

By including recommendations and examples for a matrix, doctrine may then be able to focus on the roles of commanders, fire support officers, and mortar leaders in preparing and executing the matrix. While doctrine is clear and consistent in enumerating responsibilities for the principals, there commonly seem to be some open circuits in the planning process of training units, which a matrix may serve to bridge.

TRAINING

We have found that schoolhouse training for mortar personnel tends to emphasize the technical aspects of delivering fire, at least in terms of hours devoted to the topic. Unless the total POI is expanded, however, increased hours devoted to tactical employment will come at the expense of technical skills, and we cannot conclude that this is an appropriate trade-off.

We can, however, conclude that CTC and home station training need to emphasize three key ingredients. The first is to stress the task force commander's responsibility to identify specific, appropriate missions for the mortars in terms of the effects desired on particular targets and the expected "window of opportunity" for those fires. The second

ingredient is to see that the TF fire support officer designs the linkage that will allow the mortars to execute that mission. This linkage includes associating a FIST or FO with the mortar platoon to initiate the missions, and to coordinate appropriate platoon firing positions and movement routes. The final training requirement to be emphasized is to conduct quality fire support rehearsals with mortar platoon participation. Our data support the fact that absence of any one of these factors can lead to low mortar utilization.

LEADERSHIP

One of the stratagems adopted by the Infantry branch to improve mortar platoon leadership was to make the platoon sergeant position E-8. Our data show, however, that it is almost always the case that the platoon sergeants continue to be E-7. We find that most platoon leaders in the CONUS units have had Infantry Mortar Platoon Course (IMPC) training, but that a much smaller fraction of leaders in USAEUR units have been so trained. This suggests the desirability of creating an exportable IMPC POI.

Some authors suggest that the position of mortar platoon leader may not be considered a desirable assignment by young infantry and armor officers. We can only say that the indirect fire skills required do not build on or contribute to other infantry or armor tasks. We have examined the level of responsibility placed on the mortar platoon leader, and compared those duties with the requirements of an artillery platoon leader. Both tactically and technically, the mortar platoon position is far more demanding. The suggestion has been made that field artillery officers be used to staff mortar platoon leader positions, thus building on their technical skills. However, the tactical skills necessary are of equivalent importance, and artillery officers who might be chosen for such a role should probably have had both fire support and artillery platoon leadership experience. This sequence may not be feasible in light of other career demands, and it could create additional problems as severe as the ones we are trying to solve.

ORGANIZATION

The problem one would be trying to solve in seeking an organizational solution to heavy mortar platoon effectiveness shortcomings is to better integrate mortars into task force training and missions. At least three platoon-level solutions have been proposed. The first is simply to eliminate the heavy mortars from the force. Our data can neither support nor refute this proposal. We believe that only a study of small unit combat in World War II and later can yield insights into the consequences of this action. Our own reading suggests that

the quick response and substantial weight of heavy mortar fire has proven vital to some units at critical times, but this is a matter for informed military judgment to decide.

There has been considerable debate in the professional literature of the U.S. Army as to the desirability of including heavy mortars in direct support field artillery organizations. The argument made is that organization permits concentration of assets as necessary. It is not clear that the dimensions of a modern battlefield will permit concentrated units of mortar range to effectively reach targets consistently. Our findings in this study indicate that the tendency to treat the mortars as simply another artillery unit leads to their present low level of utilization and effectiveness. Our conclusions are that the mortars should be *more* closely integrated with the lower level maneuver organizations, not *less* so.

This mortar study, as well as an earlier RAND study of scout platoons [17], indicates that special purpose units suffer from training problems at home station, and command and control problems in exercises. The issue is who is responsible for both their training and their tactical employment. In both cases, the answer is usually not the commander of the unit to which they are assigned; thus these vital functions are handled on an *ad hoc* basis. In prior times, a combat support company provided the organizational home. In a separate RAND presentation, Martin Goldsmith has argued for a separate company to contain these elements, with responsibility for reconnaissance and security functions. As the Army looks to a reconfigured future, all of these options can be considered in the context of changing requirements.

A final organizational solution involves the assignment of forward observers. Some experienced officers have stated their belief that the problems we observed in this study were much less severe when the mortar platoon had its own FOs. It was in the recent past that the FOs were consolidated into the direct support artillery battalions. We believe that the capabilities of platoon FOs are complementary to mortar capabilities but not to artillery capabilities. In fact, in Close Support Study Group IV, the Field Artillery School has recommended elimination of the mechanized infantry platoon FOs. A similar finding was made in a RAND study of artillery accuracy, based on the fact that the FOs lack the modern laser-based equipment to support accurate first-round fires that the company FIST-Vs and COLTS have.

The arguments that support the retention of FOs in the mortar platoons are:

1. Artillery systems strive for first round fire for effect. Mortars can seldom provide first round fire for effect.

2. High-tech observers (FISTs/COLTS) are equipped to support first round fire for effect. Platoon FOs generally cannot support first round fire for effect.
3. Platoon FOs operate most effectively during dismounted infantry engagements. A primary mission of the mortars is to support the dismounted infantry battle.

There are at least three options for the future of FOs. Our data do not support a strong recommendation for any particular one of the three.

1. Retain the mechanized infantry platoon FOs in the force. The impact is that mortars may continue to be underutilized unless doctrine and training emphasize the linking of FOs and mortars.
2. Eliminate mechanized infantry platoon FOs. The impact is apt to be that the mortars will become even less effective as the artillery becomes the weapon of choice for the high-tech observer. Maneuver units may be left without prompt indirect fire support during small unit actions.
3. Eliminate mechanized infantry platoon FOs but reassign some subset to the mortar platoon. We expect that mortar effectiveness may increase with the presence of dedicated observers.

Appendix A
MORTAR ORGANIZATION

In response to a variety of external influences, the U.S. Army has, over the past several decades, implemented several significant organizational changes. The rationale for these changes is discussed by historian Martin Blumenson, who argues that "reorganization continues, for the Army is an ever-changing institution designed to function in an ever-changing environment."

The organizational structures under which mortars have been fielded have certainly not been immune from this reorganization. A mechanized infantry battalion organized under the Triangular Division concept of World War II, for example, fielded one 81mm mortar and nine 60mm mortars. Under the H-series TOE of the ROAD structure, that same battalion was authorized four 107mm mortars and nine 81mm mortars. Currently, the Army of Excellence organizational design authorizes the mechanized infantry battalion six 107mm mortars, and all 60mm or 81mm mortars have been eliminated from the unit's structure. Similar evolutionary changes have been observed in every unit that fields a mortar.

It is not the intent of this Appendix to chronicle the deployment history of the mortar weapon system or to compare the relative merits of the various configurations under which mortars have been fielded. It is important, however, to recognize two facts associated with this process of evolutionary change. First, this reorganization and realignment is continuing and ongoing. Plans to field the 120mm mortar, for example, in both a towed and carrier-mounted version have been developed, and that system will replace the currently fielded 4.2-in mortar. Second, this reorganizational process has resulted in a variety of mortar unit configurations. Regimental cavalry squadrons, airborne infantry battalions, and M1 Tank battalions, for example, each have a unique organic mortar organization. This study focused on three organizational variants as they are currently employed at the CTCs:

1. The 107mm (4.2-in), heavy mortar platoon authorized to the Headquarters and Headquarters Company of the Tank and Mechanized Infantry Battalion (TOE 17-235J and TOE 17-245J).
2. The 81mm, medium mortar platoon authorized to the Headquarters and Headquarters Company of the Light Infantry Battalion (TOE 7-15L).
3. The 60mm, light mortar section authorized to the Rifle Company of the Light Infantry Battalion (TOE 7-17L).

This sample represents the majority of the mortar units currently fielded. Mortar platoons and sections in the Airborne, Ranger, and Air Assault Infantry battalions do exercise unique operational techniques but are similar in structure to the mortar organizations fielded in the light infantry battalion. Mortars authorized to ground cavalry organizations, motorized infantry battalions and Reserve Component units operating under non-modernized TOEs have a significantly different organizational structure and were not specifically addressed in this study.

The purpose of this Appendix is twofold: first, to detail the operational characteristics of the three type mortar units studied and second, to identify and discuss those issues involving equipment, organization, and employment that impact the mortar units' ability to provide close, immediate, indirect fire support to the maneuver commander.

MORTAR CHARACTERISTICS

FM 7-90 (draft) states that the primary role of mortars is "to kill or suppress enemy dismounted infantry." In order to satisfy this requirement, each mortar system is capable of firing high explosive (HE), white phosphorous (WP) and illumination (ILL) munitions. HE munitions fuzed with point-detonating or proximity fuzes are most effective in attacking dismounted infantry. WP munitions can be fired to increase the suppressive effects of HE munitions. FM 7-90 (draft) defines illumination missions and smoke missions as "subsidiary missions for mortars." The rate at which each mortar system can deliver these munitions, the range which each weapon can achieve, as well as several other operational characteristics are depicted in Table A.1. The data in the Table A.1 reflect the mortar capabilities that are currently simulated during force-on-force activities at each CTC.

One method of gauging the responsiveness of the various mortar systems is to review the time standards for a variety of operations as published in the Mission Training Plan for those systems. ARTEP 7-90-MTP is the current Mission Training Plan for the infantry mortar platoon, section and squad. As stated in the preface of this manual, the published time standards and training and evaluation outlines (T&EOs) are applicable to "the mechanized infantry, motorized infantry, light infantry, infantry, airborne, air assault, and ranger mortar platoons, sections and squads." Whether the task is applicable to a mortar platoon, section, or squad is defined in the "Element" portion of each T&EO. Of the 38 T&EOs in the MTP manual, 2 T&EOs are squad specific, 11 T&EOs are appropriate for both sections and platoons, and 25 T&EOs are applicable to all three echelons. This latter group includes the T&EOs which contain the time standards that can define the expected responsiveness of the mortar systems. These particular T&EOs do not discriminate by

Table A.1

Mortar Systems Characteristics

Wpn	Ammo Type	Min Range (meters)	Max Range (meters)	Weight	Rate of Fire in rpm (rounds/ minute)	Combat Load[a]	Basic Load[a]	Doctrinal Exp. Daily Rate Def[a]		Doctrinal Exp. Daily Rate Off[a]	
60mm	HE	70	3500[b]	Wpn - 45 lb	30 for 4 min	240	350	Heavy	145	Heavy	121
M224	WP	70	3500	Rd - 3.5 lb	20 sustained			Mod.	103	Mod.	86
	ILL	200	3500					Light	62	Light	52
81mm	HE	80	5600	Wpn - 93 lb	35 for 1 min	80	120	Heavy	145	Heavy	121
M252	WP	73	4790	Rd - 9.8 lb	15 sustained			Mod.	103	Mod.	86
	ILL	300	5050					Light	62	Light	52
107mm	HE	770	6840	Wpn - 675 lb	18 for 1 min	88	188	Heavy	163	Heavy	136
M30	WP	770	5650	Rd - 27.5 lb	9 for 5 min			Mod.	116	Mod.	97
	ILL	440	5490		3 sustained			Light	70	Light	59

[a]Combat load, basic load, and doctrinal expenditure rates are quoted in rounds per weapon. Expenditure rates are derived from FM 101-10-1 and are recognized to be planning estimates.

[b]The maximum range for the 60mm mortar in the hand-held configuration is 1300 meters.

weapon system; consequently, the time standards for all fire missions are the same for all mortar units. The manual recognizes that the 60mm mortar section does not have an FDC but indicates that "unless otherwise stated, the section or squad leader performs the tasks of the FDC." Table A.2 identifies the fire mission standards for common mission types. Also included, for comparative purposes, are the time standards applicable to a 155mm Field Artillery platoon as extracted from ARTEP 6-037-30-MTP. Time standards for the occupation of a firing position do vary by weapon type and those standards are listed in Table A.3. Again, similar standards for a 155mm Field Artillery platoon are provided for comparative purposes.

A review of these figures indicates that the mortar and artillery systems are comparable both in mission execution and occupation time. Certain considerations are not, however, explicitly depicted in the figures. The range of the 155mm howitzer is four to five times greater than any of the mortar systems. Hence, the mortars may, in certain scenarios, be required to displace much more frequently to range targets. On the other hand, the mortars are a dedicated asset of the maneuver Task Force commander and he can directly influence which targets the mortars engage at any point in the battle. He does not have to compete for mortar support as he does for field artillery support.

Table A.2

Comparative Fire Mission Time Standard (minutes:seconds)

Fire Mission	Mortar Element	155mm FA Platoon
Adjust Fire	5:00	8:10+
Fire-for-Effect	4:00	2:20
Final Protective Fires		:55
Platoon laid on FPF data	:30	
Platoon not laid on FPF data	1:00	
Priority Target		1:15
Platoon laid on target data	1:00	
Platoon not laid on target data	2:00	
Hipshoot		8:00++
Immediate Suppression	4:00	
Adjust Fire	11:00	

NOTE: 155mm FA platoon standards are based on a 4 gun platoon operating as part of a batallion equipped with TACFIRE/BCS and DMDs.

\+ Includes adjustment of time fuze and observer time.

++ Does not include time for adjustment of rounds.

Table A.3

Comparative Occupation Times

		Time	Standard
Weapon System	Time	Prepared Firing Posn	Unprepared Firing Posn
60mm Section	Day	3:15 minutes	Standard not specified
	Night	6 minutes	in MTEP manual
81mm Section	Day	3:15 minutes	6 minutes
	Night	6 minutes	9 minutes
107mm Section	Day	6:45 minutes	8 minutes
	Night	8 minutes	11 minutes
155mm FA Platoon	Day	6 minutes	8 minutes
	Night	13 minutes	15 minutes

ORGANIZATION

There is a clearly defined hierarchical structure evident in every mortar unit. Within that structure, mortar squads are consolidated to form sections, and two sections normally constitute a platoon. Mortar units are expected to deploy as squads, sections or platoons and provide effective fire support.

4.2-in Mortar Platoon

The structure of the 4.2-in (heavy) mortar platoon in both the mechanized infantry and tank battalion is depicted in Fig. A.1.

As depicted, the platoon consists of six mortar squads, two Fire Direction Centers (FDC), and a platoon headquarters. Three mortar squads and an FDC are grouped into a mortar "section," with each section designed to be capable of autonomous operations.

The platoon headquarters section consists of the platoon leader, a driver, and the platoon sergeant. Including these three individuals, the total platoon strength is 35 soldiers. The platoon leader is either an Infantry or Armor branch lieutenant, depending on the nature of the parent battalion. The position of platoon sergeant is authorized an E-8 Master Sergeant. This position was upgraded from E-7 to E-8 in an attempt to enhance the level of experience within the platoon and to create additional opportunities for upward mobility among senior non-commissioned officers in Military Occupational Specialty (MOS) 11C.

Each section is under the leadership of an E-7 Section Sergeant. One FDC is authorized to each section and is manned by three soldiers, including an E-6 Fire Direction Chief, an E-4 Fire Direction Computer, and an E-3 Carrier Driver. Each mortar squad consists of four soldiers: the E-5 squad leader, the E-4 gunner, an E-3 assistant gunner, and

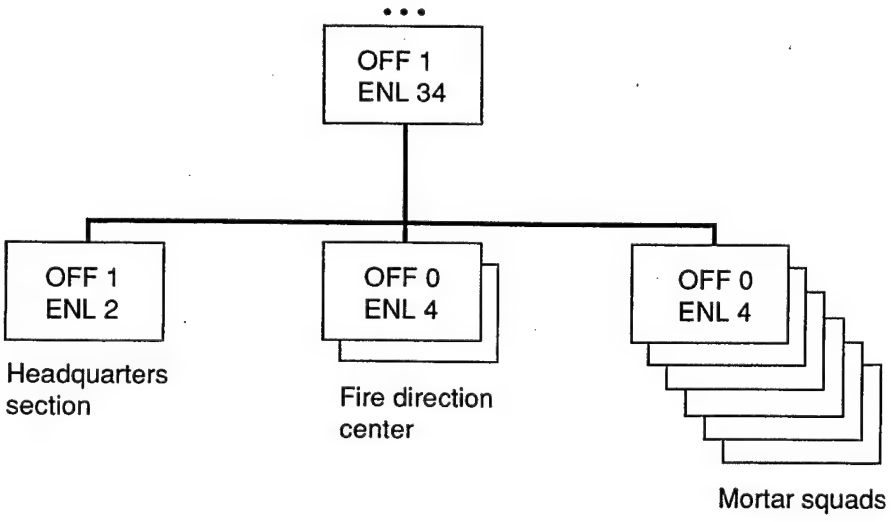


Fig. A.1—Heavy Mortar Platoon Organization

an E-3 ammunition bearer and vehicle driver. The entire section is composed of 16 soldiers, all of whom hold the 11C series MOS.

81mm Platoon

The structure of the 81mm (medium) mortar platoon is depicted in Fig. A.2. An obvious difference between the heavy and medium platoons is that the medium platoon is only authorized four mortar squads. In addition, in the medium platoon, the FDC and platoon headquarters are consolidated into one element.

Unlike the squads of the heavy platoon, each mortar squad in the medium platoon is authorized five soldiers, reflecting the addition of one ammunition bearer to each mortar squad. The platoon headquarters/FDC consists of one officer and six enlisted men, with the platoon leader normally an infantry lieutenant. The six enlisted men include an E-7 platoon sergeant, an E-6 Fire Direction Chief, two E-5 Fire Direction Computers, and two E-3 telephone operators/drivers. The total platoon strength of the medium platoon is 27 soldiers with all enlisted members holding MOS 11C.

The ability of this platoon to operate in section configuration is not as clearly supported by the organizational structure as it is in the heavy platoon. One option envisions the platoon sergeant controlling the technical fires of one section while the E-6 Fire Direction Chief controls the fires of the second section. This option, however, impacts the platoon sergeant's ability to execute one of his principal duties, orchestrating the logistical support required by the entire platoon.

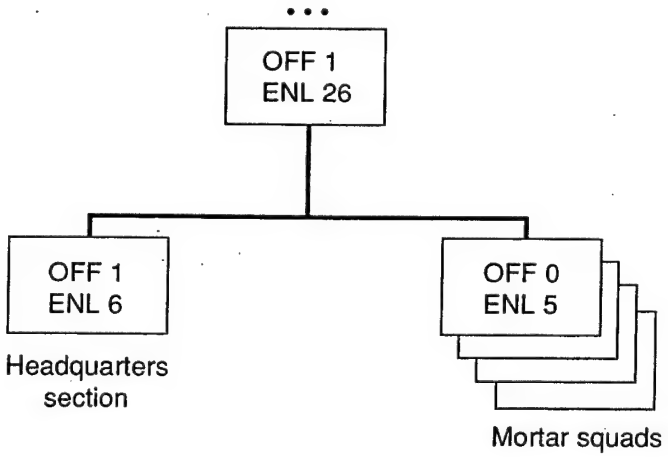


Fig. A.2—Medium Mortar Platoon Organization

60mm Section

One 60mm mortar section is authorized to the headquarters of each rifle company contained within the light infantry battalion. Consequently, within each light infantry battalion there are six 60mm mortar squads and four 81mm mortar squads. The 60mm mortar section consists of two mortar squads and has no dedicated FDC capability. The section has a total strength of six soldiers, all of whom have MOS 11C, and it is under the control of an E-6 section sergeant who is assisted by an E-5 squad leader. Each tube is manned by an E-4 gunner and an E-3 ammunition bearer. As mentioned earlier, either the section sergeant or the squad leader performs the tasks normally expected of an FDC.

ORGANIZATIONAL ISSUES

It is important to recognize that a total indirect fire support team consists of three elements: the indirect fire delivery system, the Fire Direction Center, and the target acquisition capability. As seen in the three organizational structures outlined, each mortar platoon or section has a number of indirect fire delivery systems. Each unit also has some computational capability ranging from the fully capable fire direction center in the 4.2-in mortar platoon to the very austere operation in the 60mm mortar section. Each mortar organization, however, lacks any target acquisition capability and must, in fact, depend on the forward observer teams and FIST elements from some external source, usually the direct support Field Artillery battalion. This creates a training and coordination problem for the mortar platoon leader who must have access to some target acquisition capability in order to conduct realistic training.

A second organizational issue of significance is the fact that both the heavy and medium mortar platoons are assigned to the Headquarters and Headquarters Company (HHC) of their parent battalion. The HHC of a Mechanized Infantry battalion or a Tank battalion is depicted in Fig. A.3. The HHC of the L series Light Infantry battalion is basically similar, although that organization also contains an Antitank Platoon composed of four TOW Heavy Antitank Weapons.

As seen in Fig. A.3, the HHC is an extremely large organization. Within the mechanized infantry battalion, the HHC is authorized 351 personnel. In the J series Tank Battalion, the company is authorized 300 soldiers whereas the same unit in the light infantry battalion is manned by 171 soldiers. With such a large span of responsibility among a diverse variety of sections, the HHC commander can ill-afford to spend a significant amount of time monitoring the training and operations of the mortar platoon, which comprises less than 10 percent of his command. Not only must the mortar platoon compete for the

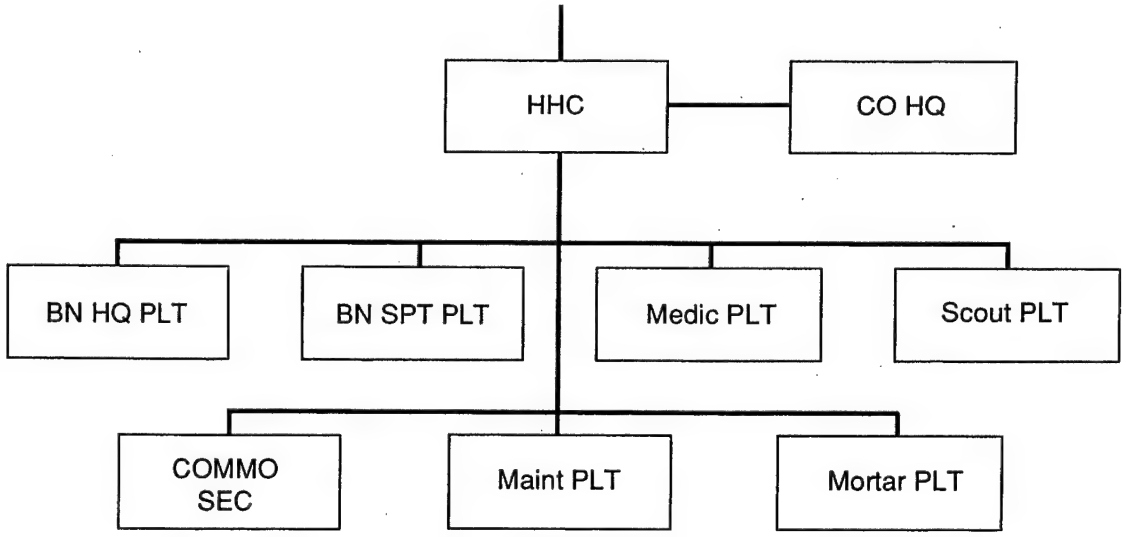


Fig. A.3—Headquarters and Headquarters Company Mechanized Infantry/Tank Battalion

commander's attention for training, it may also find itself a low priority for maintenance and logistical support, especially in the mechanized infantry and tank battalions. As a result, the mortar platoon must have a very capable, experienced officer who can independently execute a myriad of responsibilities, including the development and implementation of effective training and maintenance programs. Once his unit is tactically deployed, the platoon leader is almost completely divorced from his nominal commander and must execute a wide spectrum of duties. These duties include advising the Task Force commander on the tactical employment of the mortars; conducting reconnaissance of proposed positions; monitoring the technical computation of firing data; coordinating logistical support for the platoon; and monitoring the tactical situation to ensure that the platoon can provide effective, responsive support. FM 7-90 states that the mortar platoon leader should also be prepared to act "as the FSCOORD in the absence of one from the supporting field artillery battalion."[1] These are rather significant tasks that may require a platoon leader who has developed significant tactical acumen and exceptional managerial skills.

When the mortar platoon sergeant position was upgraded to authorize an E-8 11C Master Sergeant, the First Sergeant position of the HHC was also recoded to authorize an

[1]This statement has been deleted in the latest draft of FM 7-90.

E-8 11C. Although the intent of this decision was to create promotion opportunities and to inject mortar experience into the platoon and company, it may have created a competing demand for these NCOs, many of whom might prefer to serve as company First Sergeants rather than as mortar platoon sergeants.

The 60mm mortar sections may not face the same problems experienced by the medium and heavy platoons. Based on their assignment to the headquarters of the rifle company, they are in closer organizational proximity to the commander who expects and needs their support.

EQUIPMENT

4.2-In (107mm) Heavy Mortar Platoon

The 4.2-in mortar platoon is configured to operate efficiently as a platoon or to support autonomous section and squad operations. The principle items of equipment authorized to the platoon, sections, and squads clearly support that capability.

Each 4.2-in mortar squad is carried on an M106A1 carrier. This carrier is equipped with an AN/GRC-160 radio that allows the squad to be deployed independently and monitor the mortar fire direction net or the company command net. In addition to the squad's personnel and equipment, the M106A1 also carries 88 rounds of ammunition. The six carriers within the platoon represent the unit's entire organic ammunition haul capability. Hence, the combat load for the 107mm platoon is 528 rounds, with the remaining 600 rounds of the basic load or the bulk load carried by vehicles in the Task Force combat trains. The composition of the combat load is flexible and is usually determined by the nature of the mission. A platoon supporting a night attack, for example, may require additional illumination rounds, whereas a platoon dedicated to supporting a breaching operation may require additional white phosphorous rounds. FM 7-90 recommends that the composition of the basic load be 70 percent HE , 20 percent WP and 10 percent ILL. The only specific constraint imposed is that the M106A1 can transport only 25 WP rounds because of the necessity to store those rounds in the upright position.

The 4.2-in mortar can be fired in both the carrier-mounted mode or the ground-mounted configuration. The time standards listed in the Tables A.2 and A.3 were based on the assumption that the mortar is fired while mounted in the back of the M106A1 carrier. This option offers the obvious advantage of much quicker emplacement and displacement because the crew is only required to execute a minimum number of steps to place the mortar in action. In fact, the time standard for this task is 90 seconds from the time the carrier is stopped until the mortar is ready to fire. In the ground-mounted mode, the crew must

manhandle the various components of the firing system to establish a dismounted firing capability. This is no small task, since the complete system weighs 672 lbs. There is no published time standard for ground-mounting the mortar. In the carrier-mounted mode, the weapon is restricted to 1600-mil traverse capability from the extreme left limit to the extreme right limit. Ground-mounting allows the weapon to exercise a full 6400-mil firing capability. Ground-mounting the weapon also allows the carrier to be used for other missions, including casualty evacuation or ammunition resupply, and the unit can maintain a full firing capability even if one carrier becomes inoperative. The ability to ground-mount also allows the platoon to occupy dug-in positions while the carriers, with mounted 50-cal machine guns, deploy to defensive positions on the platoon perimeter. In either mode, the mortar squad employs aiming posts as aiming reference points. None of the mortar units studied are authorized a device similar to the M1A1 collimator for use as a reference point. There is also no authorization within any of the units for a device capable of measuring tube muzzle velocity, such as the M90 radar chronograph set.

As mentioned earlier, the mortar section consists of three tubes and a Fire Direction Center (FDC). The FDC is transported in an M577 Command Post carrier, which also carries two AN/VRC-46 FM radios and one AN/VRC-64 FM radio set. These radios allow the FDC to monitor both mortar fire direction nets as well as the Task Force command net. Each section is also authorized an aiming circle and a compass necessary for orienting the tubes and conducting hasty survey. There are no other survey or location determining devices within the section or the platoon, nor are these devices found in any of the other mortar units studied.

Each FDC is authorized two Mortar Ballistic Computers (MBC) for a total of four computers within the platoon. This computer represents a significant improvement in the capability of the platoon to compute accurate, timely firing data. Although it is designed to eliminate manual computations, each FDC will still maintain sufficient equipment to manually generate firing data. The MBC has a digital capability that allows it to interface with the forward observer's Digital Message Device (DMD) and the FIST DMD. It cannot interface directly with TACFIRE; however, it is expected to be able to communicate digitally with the Advanced Field Artillery Tactical Data System (AFATDS). Using the MBC, an operator can determine first-round data within 30 seconds and data for subsequent rounds within 10 seconds. A trained operator can be expected to input the data for six tubes and three observers in less than three minutes. The computer also has a substantial memory capacity, with the capability to store 50 targets, 3 platoon locations, 12 FO positions, 10 no-fire areas, 3 Final Protective Fires, and 16 registration points.

The platoon headquarters is equipped with two HMMWVs for use by the platoon leader and the platoon sergeant. Each vehicle is equipped with two AN/VRC-46 FM radios. The platoon sergeant requires this vehicle to evacuate casualties and to orchestrate the unit's logistical support.

81mm Medium Mortar Platoon

In the medium platoon, the only transport vehicle is the HMMWV and the platoon is authorized six of these carriers. Each mortar squad is authorized one HMMWV, equipped with an AN/GRC-160 radio. The squad HMMWV also carries a combat load of 80 rounds. As in the heavy platoon, the squad vehicles represent the only organic ammunition haul capability and allow the platoon to transport a total combat load of 320 rounds. The bulk load of 160 rounds is transported in the Task Force combat trains. Again, the recommended composition of the basic and combat load is METT-T dependent, but a mix of 70 percent HE, 20 percent WP and 10 percent ILL is considered the most flexible.

The 81mm mortar must be fired in the ground-mounted mode in which it has a 6400-mil traverse capability. It is, however, substantially lighter than the 4.2-in mortar and establishing a ground-mounted capability is much less demanding on the crew. When traveling, the mortar is disassembled and carried on the HMMWV in three components: the barrel (28 lbs), the mount (40 lbs), and the baseplate (25 or 48 lbs). Upon arrival at a firing position, the crew dismounts and assembles the weapon. As is the standard for all mortars, the time required to assemble the mortar and to place it in action is 90 seconds. Each squad is also equipped with a compass and a plotting board to support autonomous operations.

As noted earlier, the organization of the medium platoon headquarters is significantly different from that of the heavy platoon based on the consolidation of the headquarters and fire direction center. This combined element is equipped with two HMMWVs necessary to transport the seven soldiers in that section and to provide a command and control vehicle to each section as necessary. Two aiming circles and two compasses are also authorized for autonomous section operations. This element is equipped with Mortar Ballistic Computers as well as manual computation equipment. An AN/VRC-47 FM radio is mounted in each HMMWV, which allows the platoon or each section to monitor all appropriate radio nets. Two AN/PRC-77 FM radios are also authorized to supplement the communications assets and to support dismounted operations.

60mm Light Mortar Section

The 60mm mortar section is not authorized any transport capability, so the equipment is entirely man-portable. The section is only authorized one AN/PRC-77 FM radio, which is used to monitor the company command net. The presence of only one radio tends to preclude independent squad deployment. FM 7-90 (draft) discourages employment by squad because of the limited destructive power of a single 60mm mortar. The section is not authorized an aiming circle and primarily uses the authorized compass to orient the tubes for indirect fire. The section is equipped with two Mortar Ballistic Computers as well as the back-up M16 Plotting Board for the computation of firing data.

The requirement that all equipment be man-transportable creates a unique challenge for the 60mm mortar section. This challenge is further complicated by the system's high rate of fire, and the need to transport sufficient ammunition for the weapon. The section sergeant can influence the amount of equipment carried and the resultant load imposed on the section members by recommending different firing configurations for the mortar. Those firing options include:

1. Complete system including cannon, M7 baseplate, bipod, sight, aiming poles, and full FDC capability.
2. Complete system including cannon, M8 baseplate, bipod, sight, aiming poles and full FDC capability. This option results in a weight reduction of approximately 11 lbs per squad but prevents the mortar from exercising a full 6400-mil traverse capability.
3. Handheld system including only cannon and M8 baseplate. This option results in a weight reduction of approximately 35 lbs per squad but significantly reduces the range of the weapon and precludes accurate indirect fire.

The first two options can be altered by eliminating the MBC from the section load and just employing the M16 Plotting Board. This results in an additional weight reduction of 16 lbs.

A very careful and detailed analysis of this problem is discussed in Ref. 9. In that article, the author identifies the weight of each individual item of equipment authorized to the section and concludes that the complete equipment authorization for the section weighs 220 lbs. If this total weight is equally divided among the members of the section, each soldier would be required to carry approximately 37 lbs of section equipment in addition to 34 lbs of personal equipment, which includes food, water, and clothing. This represents a total load per mortarman of 71 lbs before any ammunition is distributed for transportation. The

section is expected to carry ammunition for immediate fire support and even if that number is as few as six rounds per man for a total of 36 rounds, the weight carried by each mortarman is 75 lbs. In contrast, FM 7-70 specifically states that "commanders must insure that soldiers carry no more than 48 lbs when in contact with the enemy or when enemy contact is expected. At other times, the soldier's load should not exceed 72 lbs."

Interestingly, FM 7-90 (draft) defines the combat load for the 60mm section as 240 rounds per weapon system. That text identifies a number of options for carrying these munitions, including field expedient transportation methods. It does not, however, specify the size of the combat load to be transported, nor what load should be imposed on each soldier. It does recommend that in an offensive operation, the mortar section should move behind the lead platoon with only the riflemen of the following platoons carrying one or two mortar rounds. If the 48 lbs combat weight restriction is imposed, this option accounts for no more than approximately 108 rounds, or 45 percent of the prescribed combat load.

OPERATIONS

Tactical Fire Control

The maneuver commander has two sets of options he must consider when incorporating the mortar elements into the operational plan. One set of options includes both support and command relationships and the second set addresses employment options.

Support relationships are defined by assigning *priority targets* or *priority of fire* to subordinate units. Priority of fire creates a unit-oriented focus, whereas a priority target mission creates a geographic focus. Under the priority target relationship, the mortar platoon must immediately respond to any mission generated by the unit assigned priority of fire. Missions for other units are conducted as time permits. Under the second alternative, the mortar platoon must be ready to engage the particular target no matter who initiates the request. Other missions are interrupted in order to attack this target. Due to the expected level of response, a section is never assigned more than one priority target. However, it is not unrealistic to assign both missions to a platoon. For example, Team A has priority of fire and target AB1001, which lies in Team A's sector, is identified as a priority target. The mortar platoon can fire in general support of the Task Force until an element of Team A requests fire support. At that point, all other missions are cancelled to support Team A. If target AB1001 is called at any time, all missions, including those from Team A, are interrupted and target AB1001 is engaged. Either relationship should influence the mortar platoon's position selection since the tubes must be able to either range the priority target at all times or provide coverage to the supported unit. The ammunition carried by the platoon

should reflect the guidance issued on the method of attack. Under either option, however, the commander still plays an active role in controlling the fires of the mortars.

Command relationships are established when the mortar platoon cannot support the battalion while remaining under battalion control. The examples offered in FM 7-90 (draft), e.g., a raid, a detachment left in contact, imply a physical separation that exceeds the range of the mortar system. The two possible alternatives, operational control (OPCON) or attachment, vary by the degree of control exercised by the supported commander. Under the attachment relationship, the supported commander provides administrative and logistical support to the mortars, although he does not incur that requirement under the OPCON relationship. Under either alternative, the supported commander may establish priorities of fire or identify priority targets. Under both options, the mortar platoon establishes direct communications with the supported unit. One possibility, which is not explored in FM7-90 (draft), is utilizing the OPCON option to provide more efficient support to the battalion regardless of any distance consideration. Consider the benefit of establishing an OPCON relationship with the company team that is assigned a critical mission, such as the supporting force of a breaching operation. Under that arrangement, the company commander has the dedicated support of the mortar platoon without the concerns associated with the requirement to provide administrative or logistical support. More important, he can expect immediate, responsive fire support without the fear that a critical mission will be delayed in the TACFIRE queue. The mortars are clearly integrated into the maneuver and fire plan and can effectively tailor their combat load and identify their firing positions to provide optimal support. The available field artillery is then allowed to direct its efforts to deeper targets in support of the assaulting forces.

Employment options can be considered a parallel set of choices for the commander. Deployment by squad, section, or platoon can be exercised under any of the support or command relationships. The first option, employment by squad or lone mortar tube, offers the advantage of increased survivability, reduced terrain requirements, and the ability to support a Task Force deployed over a wide front. This option is not considered appropriate for the light mortars. On the other extreme, employment by platoons of six or four tubes reflects a desire for centralized control and provides an enhanced ability to mass fires and simplifies both logistical support and 24-hour operations. The third option is employment by section or groups of two to three tubes and this represents a compromise between the first two options.

Technical Fire Control

The field artillery community has expended a great deal of effort in attempting to achieve an accurate, first-round, fire-for-effect capability. Such a capability has obvious benefits, to include increased effect on the target as surprise is achieved, reduced ammunition expenditure and reduced vulnerability to firing units from hostile target acquisition assets. According to TC 6-40, there are five ingredients necessary to achieve first round fire-for-effect accuracy. These ingredients are depicted in Fig. A.4 and are applicable to any indirect fire source to include the three mortar systems studied.

The first ingredient is accurate computational procedures. The computed firing data must be error-free, and the Mortar Ballistic Computer has eliminated the introduction of human error (except for keying errors), which often played a significant role in the manual computation of firing data. Unfortunately, this is the only ingredient for accurate first round fire for effect that the mortar units possess.

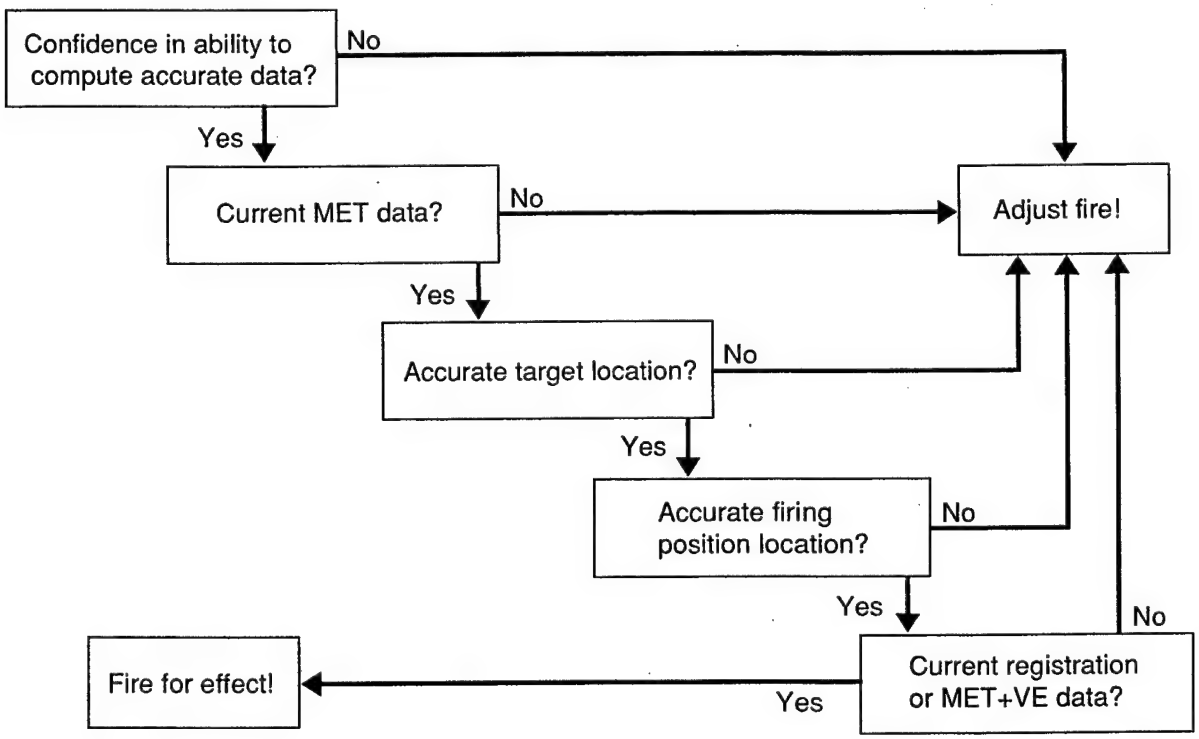


Fig. A.4—Criteria for "Adjust Fire" vs. "Fire-for-Effect" Missions

As a weapon system that fires high-angle missions with a long time of flight, a mortar is particularly vulnerable to the effects of weather. TC 6-40 clearly argues that the "effects of weather on the projectile in flight must be considered, and firing data must compensate for those effects." Unfortunately, it appears unrealistic to expect a mortar unit to receive a correctly formatted current MET message, which is one of the key ingredients for accurate first-round fire-for-effect data. MET messages are created by the MET section organic to the division artillery or the FA brigade headquarters. They normally prepare the type message required by the TACFIRE computer system, which is the computer MET message recorded on a tape readable by the TACFIRE computer. This version of the MET message is not, however, readily compatible with the MBC.

The next two ingredients are similar in that they address the problem of location determination, in particular, the ability of the forward observer to accurately identify the location of the target and the ability of the mortar platoon leader to accurately identify the location of the firing platoon. The ability of the FO to accurately identify a target's location is discussed in great detail in a RAND Note [1], which concluded that it is unreasonable to expect an unassisted observer to achieve a mean target location error of less than 500 meters. In addition, data contained in that same report indicate that the mean error in self-location is approximately 180 meters. This is particularly significant as the mortar platoon is not equipped with very sophisticated equipment to accurately determine the location of the firing position. A map, compass, and aiming circle are the tools readily available to the mortar platoon leader. The position and azimuth determining system (PADS), which is an essential tool during the conduct of a position occupation by a field artillery platoon, is usually not available to support the mortar platoon. Hasty survey techniques, which could reduce the location error, are not discussed in the published version of FM 7-90. A draft version of FM 7-90 recommends the use of hasty survey techniques to minimize location error and also recommends, if possible, the use of friendly artillery radar to accurately locate the firing position.

Finally, the unit must be able to either measure the performance of the firing weapon or conduct a registration. The field artillery firing battery is expected to have accurate muzzle velocity data for each howitzer in the platoon by using the authorized M90 velocimeter. Unfortunately, mortar platoons are not authorized a device of similar capability, yet mortar tubes are subject to the same factors that affect muzzle velocity, to include barrel wear, new weapon tolerance, etc. In fact, FM 23-91 states that "if a battalion armed with new mortars fired with a common lot of ammunition, a velocity difference of 3–4 meters per second between the mortar with the highest muzzle velocity and the mortar with

the lowest muzzle velocity would not be unusual." Hence, one would expect mortar units to conduct frequent registrations. Depicted in Fig. A.5 is the decision process to determine whether or not a registration is necessary. The logical conclusion from both charts is that mortar platoons should routinely conduct registration missions or should only fire adjust fire missions.

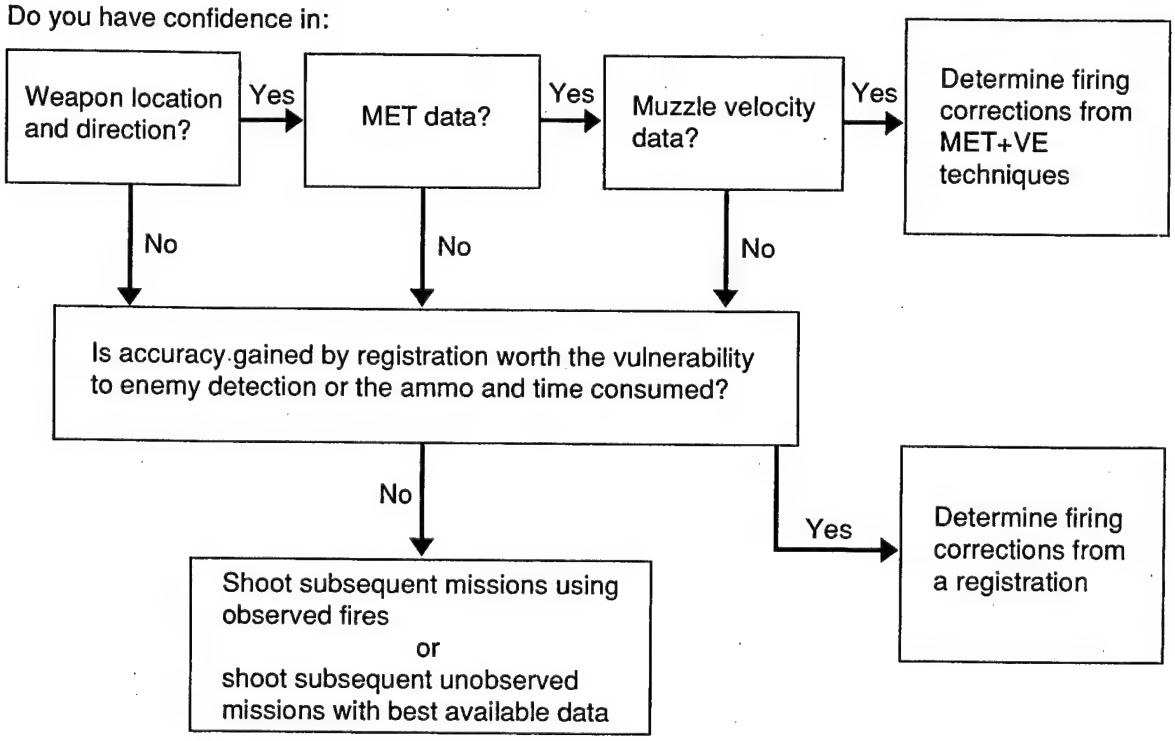


Fig. A.5—Registration Decision Diagram

Ammunition Control

Every issued fire order must include the type and amount of ammunition to be fired in support of the mission. When Field Artillery units are working in the automated mode, the TACFIRE computer system determines the number of rounds to fire based on information in the computer database and utilizing whatever "commander's modifications" have been entered. When these units are required to work in the manual mode, the Joint Munitions Effectiveness Manuals (JMEMs) are available to determine attack criteria. However, TC

6-40 clearly argues that these volumes are not recommended for use in the field. In fact, the manual recommends that the unit use the condensed version of the JMEMs known as the Graphical Munitions Effects Tables (GMETs). These are "slide-rule" versions of the JMEMs that allow rapid determination of the number of volleys required to achieve a specified casualty rate. Unfortunately, no similar device or table exists for the mortar platoon. FM 23-91 does include a discussion entitled "Amount and Type of Ammunition" but it provides no definitive guidance on how to determine the amount of ammunition required to achieve a particular effect on the target. Table A.3 of the same text, "Targets and Methods of Attack," identifies the most effective shell and fuze combination but does not give guidance for the number of rounds or volleys required. FM 7-90 (draft) contains an excellent discussion of the effects of a variety of mortar munitions. It does not, however, lay out a clear algorithm for determining the amount or type of ammunition required to defeat typical targets.

LEADERSHIP

Armed with a basic understanding of the organization and equipment of a mortar unit, some very interesting insights are gained if we compare the role of the mortar platoon leader to the role of a field artillery cannon platoon leader. This comparison is motivated by the similar structure and similar mission of both types of unit. Each platoon is designed to provide indirect fire in support of a combined arms operation. Both platoons are designed to respond to the same event, that is, a request for fire initiated by a forward observer or FIST. Both platoons must maneuver to remain within range of the expected targets, and the basic procedures for accomplishing that movement, i.e., reconnaissance, selection, and occupation of position are remarkably similar. In fact, the techniques for orienting the weapons of the platoon are exactly the same and employ the same equipment. Both elements must solve the "gunnery problem" to accurately fire their weapons; certainly, mortar gunnery is every bit as difficult as field artillery gunnery. Despite these strong similarities, there are some significant differences that must have an impact on the performance of the mortar platoon. Consider the following:

- The field artillery platoon is seldom tasked to operate in other than a platoon configuration, i.e., to demonstrate any split unit capability except for selected missions, such as offset registration. The mortar platoon, as we have seen, is expected to be able to deploy and provide fire support as a platoon, section, or independent squads. Employment by section or squad presents some unique

training and command and control challenges that do not concern the field artillery platoon leader.

- The range of the weapons systems in question are significantly different. Again, the range of the howitzer is four times that of the 4.2-in mortar. As a result, the mortar platoon must displace more frequently to remain within effective supporting range of the units in contact. More importantly, however, the mortar platoon is expected to understand the battalion commander's intent and plan position and routes and direct mortar displacement in order to support the maneuver commander's plan. He is expected, by doctrine, to develop the plan that will ensure that the mortar platoon is in position to provide the necessary fire support. The field artillery platoon leader, on the other hand, is not expected to independently initiate any movement except possibly when his position is under enemy attack. The movement of the field artillery platoon is a carefully orchestrated effort coordinated by the field artillery battalion S-3. The field artillery platoon leader selects subsequent positions for his element only after the S-3 has designated a "goose-egg" for consideration and the firing battery commander has provided more specific position selection guidance.
- The field artillery platoon is imbedded in a command structure that is designed to support the activities of the platoon. Platoons are combined into batteries that are commanded by a field artillery captain who is doctrinally responsible for supervising the training of the platoons, assisting in the reconnaissance and selection of position, and coordinating both administrative and logistical support. Each battery has a First Sergeant whose primary duties include directing the training of the NCOs within the unit and providing administrative and logistical support to the platoon. The chain of command at battalion level is filled by officers and NCOs who have had experience at the platoon and battery level. The howitzer is the key pacing item in the battalion and therefore the focus of the maintenance assets is directed toward the readiness of that weapon. The mortar platoon leader, on the other hand, does not benefit from a similar support structure. The mortar platoon is an indirect fire system in a direct fire unit and may be unintentionally neglected. The unique ammunition and maintenance requirements of the platoon must be coordinated by the platoon leader who may have difficulty competing with the demands of the higher-priority systems. There is no guarantee that anyone else in the mortar platoon leader's chain of command has any experience in his duty position.

- The field artillery platoon leader is not expected to participate in the fire planning process. The focus of his efforts is ensuring that his elements are prepared to execute assigned missions. On the other hand, the mortar platoon leader is expected to play an active role in the planning process and although FM 7-90 states that the mortar platoon leader has no formal fire planning responsibility, he must "be knowledgeable about fire support planning coordination because he will act as the FSO or FIST chief in their absence."
- The position of Field Artillery (FA) platoon leader is a highly desired position. FA lieutenants compete to be selected for this job. On the other hand, conversations with combat arms officers indicate that the mortar platoon leader position may be less attractive than other duty assignments within the maneuver battalion.
- As discussed throughout this appendix, the field artillery platoon leader has access to a variety of equipment that enhances the platoon's performance, including PADS, velocimeters, MET information, and digital links from the FDC to each howitzer. These devices are simply not available to support the mortar platoon leader.
- The Field Artillery platoon leader receives extensive formal training in his duties. The purpose of the six-week Field Artillery Cannon Officer Basic Course, a follow-on to the Field Artillery Officer's Basic Course, is to prepare the lieutenant for his duties as platoon leader. In addition, most platoon leaders have served as platoon-level fire direction officers, a position in which they are able to refine their gunnery skills while being exposed to the duties of the platoon leader. Again, the entire chain of command of the artillery battalion is composed of officers and NCOs who are familiar with the duties of the platoon leader and can provide assistance as needed. The mortar platoon leader may find himself working for a chain of command that has no first-hand experience with the employment of mortars and does not possess a clear understanding of their capabilities and limitations. He may, along with all the senior leadership of the platoon, have the opportunity to attend the Infantry Mortar Platoon Course (IMPOC) offered at the U.S. Army Infantry School. This is a five-week, four-day course that provides instruction in "the tactical employment of the Infantry Mortar Platoon, graphics, fire planning, mechanical training and field firing exercises, forward observer procedures, fire direction center procedures, and the mortar ballistic computer." Formal prerequisites for the course allow all non-

commissioned officers in the ranks of sergeant to master sergeant who are serving with a mortar unit to attend. CONUS-based lieutenants must have one year of prior infantry or armor/cavalry platoon leader time. OCONUS assigned lieutenants must be identified as *potential mortar platoon leaders*. The course consists of 266 instructional hours of which 34 are administrative and 232 are academic. The breakdown of the academic hours are as follows:

TOPIC	HOURS
Tactical employment	12
Artillery operations	10
Graphics	2
Mechanical training & field firing	66
Forward observer procedures	12
Fire direction center procedures	50
Maintenance	8
Mortar ballistic computer	48
Student evaluation (examinations)	24

The course listing clearly indicates that the bulk of the instruction is very technical in nature. Tactical issues are addressed primarily in the first three blocks of instruction, i.e., tactical employment, artillery operations, and graphics; and it is in these lessons that the platoon leadership is exposed to issues concerning position selection, command relationships, fire planning, and fire support coordination. Unfortunately, these blocks only represent 10 percent of the course academic time. There is a 33-hour Field Training Exercise included in the block of instruction identified as Mechanical Training and Field Firing; however, the Program of Instruction indicates that the primary training objective for that event includes supervising a 107mm, 81mm and 60mm mortar section during the conduct of fire. It indicates that the student will spend the majority of the training time filling various duty positions within each section type during the conduct of live fire.

The objective of this comparison was not to demean the responsibility of the field artillery platoon leader or to support a recommendation that the command and control structure of the field artillery platoon be altered. Certainly, experience has shown that the effective deployment of a field artillery platoon is no trivial task. Rather, the more obvious conclusion to be drawn must be that unrealistic expectations for the mortar platoon leader may be the cause of disappointing results.

Appendix B
DATA SELECTION AND COLLECTION

INTRODUCTION

An earlier RAND Note [18] lists different data forms that may be generated during the course of a unit's rotation at the NTC. However, for the purposes of this study, many of those possible data sets were analytically intractable, unavailable, or provided few, if any, insights into the performance of the mortar platoons. As a result, this study primarily employed two separate sets of data. The first included elements of the data generated at the CTCs, which is currently available from the Army Research Institute archives, and the second was derived from field data cards generated specifically for this study and completed by the CTC Observer/Controller teams.

ARCHIVAL DATA

Table B.1 displays the type of information maintained in the ARI archives and whether or not that data source is generated at each CTC. The After-Action Videos and the tapes of the communications nets and graphic terminal displays were not exploited as a source of data and information. These sources tend to concentrate on the key events at the Task Force level but provide little information on the detailed performance of the mortar system. The remaining data types did, however, prove to be very useful sources of information concerning the performance of the mortars.

Table B.1

Archival Data

	NTC	JRTC	CMTC
Written Take Home Package	Y	Y	Y
After-Action Videos	Y	Y	Y
Operations orders	Y	Y	Y
MTP performance data	N	Y	N
Tapes of commo nets & terminal displays	Y	N	N

NOTE: RAND also maintains a limited library of Take Home Package reports, AAR videos, and terminal graphics tapes.

Written Take-Home Packages

As evident from the table, each of the CTCs currently prepares a written Take Home Package for the player unit. There is not, however, a clearly defined, standard format for the written portion of the THP. As a result, the written reports vary significantly between CTCs

and, even for a particular CTC, the information contained in the report is characteristic of any data obtained through unstructured observation methods. While the reports include a rich summary of the events of the battle and often provide interesting and insightful anecdotes, they clearly can reflect the bias of the observer and for the most part do not provide any systematically collected data that can serve as the basis for analysis. The purpose of the THP, after all, is to guide training, not to provide research data. However, the written THPs for both the CMTC and the NTC contain summary tables for the participating indirect fire systems that detail the number of missions fired, the amount of ammunition consumed, and the overall effectiveness of the field artillery and mortar systems. These summary tables were reviewed and the performance data were derived for analytical use.

NTC THP Data. The THP from the NTC contains one enclosure that addresses fire support issues and contains the fire support summary tables. These tables are compiled by the Fire Support Trainers (Werewolves) who monitor the activity of the Direct Support Field Artillery (DSFA) battalion participating in the training rotation. Hence, the data in the summary tables only address those battles in which the DSFA battalion is an active player, including the brigade-level force-on-force exercises and the live fire exercises. The fire support section of the summary data in the THP covers the participation in the live fire scenario of the DSFA battalion and the heavy mortars organic to the participating Task Force. A second part includes statistics quantifying the performance of those indirect fire support assets participating in the brigade-level force-on-force operations.

We made a conscious decision early in this research not to use live fire data from the NTC. Nonetheless, observations of live fire exercises and examination of THP discussion of live fire offered valuable insights. Our rationale for the data exclusion decision, as well as coverage of our live fire observations and review, are included in Apps. C and D.

Table B.2 contains data describing the performance of the indirect fire systems participating in the brigade-level force-on-force operations at the NTC. It was derived from a review of 21 rotations and contains data from 62 battles. It lists the following information:

- An arbitrarily assigned battle number and mission type designator (MSNTYPE), which identifies defense in sector missions (DIS), deliberate attacks (DA), movement to contact missions (MTC), and hasty attacks (HA).
- The total number of missions fired by system type.
- The total number of HE missions fired by system type. (This excludes those smoke and illumination missions for which effectiveness is not determined.)
- The number of HE rounds fired in the battle.

Table B.2

NTC Mission Data

			FIELD ARTILLERY						MORTARS							
BATTLE	MSNTYPE	TOTAL MSNS	HE MSNS	#RDS	#EFF MSNS	#SUPP MSNS	# MRTR PLTS	# IDLE	TOTAL MSNS	HE MSNS	#RDS	#EFF MSNS	#SUPP MSNS	PLTGTFA	PLTGTMTR	TOOFA	TOOMTR
1	DIS	12	2		1	1	1	0	1	1		0	1				
2	DIS	15	6		3	2	1	0	3	2		1	0				
3	DA	20	8		4	0	1	0	1	1		0	1				
4	MTC	42	39		7	14	2	0	18	13		2	3				
5	DA	101	92	2930	23	33	2	0	22	14	556	0	0				
6	DA	111	102	4312	20	32	2	0	29	22	564	5	2				
7	MTC	65	61	2595	11	27	2	0	32	28	976	3	4				
8	DA	31	19	1882	8	3	2	0	6	3	80	3	0				
9	DA	84	51	3437	14	13	2	0	4	4	448	0	0				
10	DA	168	157	3135	20	15	2	0	10	6	140	0	1				
11	DA	79	51	1571	15	13	2	0	20	10	444	0	4				
12	MTC	64	61	4300	5	10	2	0	10	5	532	0	0				
13	DA	88	76	4639	8	38	2	0	7	3	428	1	0				
14	DIS	17	13	492	6	2	1	0	0	0	0	0	0				
15	DIS	14	11	657	6	5	1	0	1	4	30	1	0				
16	DIS	34	30	2144	6	9	2	0	9	8	810	2	0				
17	DA	49	40	1859	8	23	2	0	25	13	487	1	7				
18	DA	47	30	3784	6	13	2	0	35	22	1260	0	4				
19	DIS	27	21	1299	5	7	2	0	9	8	308	1	0	8	0	19	9
20	MTC	24	18	1367	4	7	2	0	12	8	328	0	1	8	0	16	12
21	HA	53	30	1797	7	12	2	0	9	7	300	1	3	10	0	24	9
22	MTC	40	37	1249	4	12	2	0	9	8	222	0	0	10	0	30	9
23	HA	89	88	2712	13	27	2	0	42	29	635	3	8	21	8	68	34
24	HA	86	81	2640	18	21	2	0	15	8	242	2	4	4	0	82	15
25	MTC	43	42	2794	10	10	2	0	16	14	376	2	0	21	0	22	16
26	HA	45	37	2065	5	13	2	0	16	11	78	0	1	31	0	14	16
27	DA	60	54	3494	11	21	2	0	11	8	220	3	1	22	0	38	11
28	DA	99	95	2413	24	24	2	0	11	11	450	0	1	44	0	55	11
29	DA	73	71	2181	11	17	2	0	14	10	562	0	1	45	0	28	14
30	MTC	72	70	2962	12	13	2	0	12	10	737	2	2	45	0	27	12
31	HA	33	33	2687	14	11	2	0	8	8	215	1	3	0	0	33	8
32	MTC	17	17	1653	1	9	2	0	3	3	452	1	0	2	0	15	3
33	NA	60	56	3191	10	15	2	0	19	14	934	1	1	29	3	31	16
34	MTC	48	48	1775	7	7	2	0	8	8	285	1	1	20	0	28	6
35	HA	78	67	2296	18	23	1	0	1	0	0	0	0	34	0	44	1
36	DA	111	106	4556	28	47	2	0	6	3	700	0	0	55	3	56	3
37	DA	38	33	2339	14	7	2	1	7	3	105	0	1	16	0	22	7
38	HA	53	52	3931	15	22	2	0	33	29	800	3	2	11	4	42	29
39	HA	36	35	2477	13	11	2	0	6	5	295	0	2	16	0	20	6
40	DA	92	83	2940	11	23	2	0	27	20	338	2	9	50	4	47	23
41	DA	18	18	549	1	12	2	1	13	11	205	3	6	7	0	11	13
42	HA	76	66	4269	11	27	2	0	20	15	427	0	6	53	1	23	19
43	DA	146	124	3084	23	66	2	0	11	10	312	2	5	92	0	54	11
44	DA	86	78	2894	10	20	2	0	12	8	460	1	1	37	0	49	12
45	HA	96	91	2785	14	42	2	0	24	21	545	2	5	43	0	53	24
46	DIS	11	10	860	1	2	1	0	8	8	264	2	1	1	0	10	8
47	DA	97	86	3455	11	28	2	0	21	12	531	0	1	20	0	77	21
48	DA	50	45	3258	11	16	2	0	16	11	355	1	3	14	0	36	16
49	DIS	24	19	1352	10	2	2	0	19	13	269	1	3	6	0	18	19
50	MTC	31	29	1437	6	6	2	0	11	11	186	2	1	9	0	22	11
51	HA	55	46	2164	6	11	2	0	21	18	374	0	2	8	0	47	21
52	MTC	47	43	1504	11	4	2	0	5	3	105	0	0	15	2	32	3
53	DA	114	109	4515	17	42	2	0	17	13	441	0	5	38	0	76	17
54	NA	34	29	868	8	16	2	1	3	1	20	0	0	19	3	15	0
55	DA	65	60	2872	9	15	2	0	14	10	398	2	2	39	0	26	14
56	DA	25	21	882	4	6	2	0	5	3	56	1	0	2	0	23	4
57	DA	35	33	1278	3	13	2	0	10	7	220	0	5	13	0	22	10
58	MTC	37	30	2417	7	12	2	0	10	9	393	1	1	10	1	27	9
59	DA	61	47	2092	13	11	2	0	13	9	314	1	4	21	7	40	6
60	DIS	28	21	711	6	15	1	0	3	2	44	1	0	23	3	5	0
61	DA	45	40	2481	7	16	1	0	4	4	217	2	0	23	0	22	4
62	HA	51	47	2554	13	11	2	0	9	6	165	0	3	22	3	29	6

- The number of effective and suppressive fire missions.
- A distribution of missions fired by target type, where the possible target types include both planned targets and targets of opportunity. Hence, the category "PLTGTFA" indicates the number of fire missions which were fired by the Field

Artillery at planned targets, while the category "TOOMTR" contains a count of the number of mortar missions which were fired at targets of opportunity.

- Data listed for the mortars represent the total contribution of all heavy organic mortar platoons participating in a particular battle. The number of platoons for which data has been collected is listed under the variable "# MRTR PLTS" and subsequent columns contain the combined performance data. For example, the total missions fired by the two platoons participating in battle #36 is 6. If one of the participating mortar platoons sat idle throughout the battle and did not provide any fire support, then an entry other than 0 should appear in the column labeled "# IDLE" (see battle #41).

CMTC THP Data. The performance data available from the CMTC is based strictly on force-on-force operations. One Task Force participates in those operations and is supported by both direct support and reinforcing artillery assets. Table B.3 contains the following performance data extracted from the THPs for a sample of 32 battles:

- the numbers of field artillery missions fired
- the number of HE rounds fired by the player artillery units
- the number of mortar missions fired
- the number of mortar rounds fired by the participating mortar platoon
- the number and type of enemy systems or personnel that the mortars destroyed, killed, or suppressed.

In addition, each THP contains a summary chart prepared for unit AARs and compares, by indirect fire system, the number of targets planned (FA-PLA or MTR-PLA), the number of planned targets that the system actually engaged (FA-PLS or MTR-PLS), and the number of targets of opportunity engaged by the weapon system during the course of the battle (FA-TOO or MTR-TOO). This information was obtained from operations group files and is displayed in Table B.4 for 56 different battles. Each of the battles is identified by an arbitrarily assigned battle number and the type of tactical mission conducted.

Operations Orders

Operations orders generated by eight different Task Forces participating in training rotations at the NTC were reviewed. We assumed that these orders documented the intentions of the Task Force commander and could be used to compare the plans for the employment of the mortar platoon to current doctrinal employment techniques. In addition,

Table B.3

CMTC Fire Mission Data

BATTLE	# FA MISSIONS	# FA ROUNDS	# MORTAR MISSIONS	# MORTAR ROUNDS	MORTAR BDA SUPPRESSED	MORTAR BDA DESTROYED
1		928	0	0	0	0
2	34	1750	1	0	0	0
3	21	1000	18	171	1 T80/3 BMP	0
4	10	200	0	0	0	0
5	27	686	7	76	0	0
6	13	520	6	138	2 T80/1 BMP	0
7	26	1000	6	95	2 BMP	0
8	32	1396	5	71	0	0
9	34	1256	1	40	0	0
10	10	580	0	0	0	0
11	25	2092	5	108	2 BMP	1 BMP/8KIA
12	8	212	0	0	0	0
13	12	336	2	12	0	0
14	20	1419	17	324	1 BMP	7 KIA
15	22	2594	11	112	1 T80/1 BMP	0
16	15	568	3	39	0	0
17	34	2052	5	23	0	0
18	38	1466	2	50	0	0
19	46	2766	17	180	7 T80/7 BMP	2 KIA
20	34	1719	12	225	0	1 KIA
21	15	721	2	48	0	0
22	15	801	11	158	2 BMP	0
23	17	623	4	150	1 BMP	0
24	25	420	4	150	0	0
25	18	672	5	308	3 BMP	1 BMP
26	38	576	8	192	0	0
27	6	596	10	162	5 BMP	0
28	21	1668	8	103	2 T80	0
29	35	2892	11	220	3 T80/1 BMP	0
30	33	2336	20	610	4 INF	4 ATGM/10 KIA
31	46	1694	9	128	0	0
32	70	3562	21	570	1 BMP	5 KIA

Table B.4

CMTC AAR Data

THIS IS A LISTING OF DATA RECEIVED FROM CMTC
IT COMPARES FA AND MORTARS IN TERMS OF
MISSIONS PLANNED, MISSIONS FIRED & TGTS OF OPP
BATTLES ARE NUMBERED ON INPUT SHEETS PROVIDED BY
CMTC FA TAF OFFICER
BATTLES OCCURRED 6 AUG 89 TO 3 JUN 90

FOR VARIABLE MSNTYP 1= MTC, 2 = DA, 4 = DEF

MSN NO	MSNTYP	MSN NO	MISSION TYPE	FA-PLA	FA-PLS	FA-TOO	MTR-PLA	MTR-PLS	MTR-TOO
1	4	1	DEFENSE	48	18	17	0	8	13
2	2	2	ATTACK	44	24	21	0	2	3
3	1	3	MTC	15	0	0	0	0	5
4	4	4	DEFENSE	36	7	15	4	0	2
5	2	5	ATTACK	24	10	14	2	2	3
6	4	6	DEFENSE	14	4	19	0	0	4
7	1	7	MTC	13	0	6	0	0	0
8	4	8	DEFENSE	18	2	42	0	0	6
9	2	9	ATTACK	30	14	9	9	0	7
10	4	10	DEFENSE	30	24	26	0	0	11
11	1	11	MTC	24	2	3	0	3	5
12	2	12	ATTACK	36	18	8	0	1	6
13	1	13	MTC	32	8	7	0	0	0
14	4	14	DEFENSE	46	32	13	0	0	2
15	1	15	MTC	23	19	2	0	1	1
16	1	16	MTC	43	14	15	1	0	11
17	4	17	DEFENSE	38	18	6	0	0	9
18	1	18	MTC	15	6	35	0	0	10
19	1	19	MTC	50	3	10	0	0	0
20	4	20	DEFENSE	56	30	6	0	0	9
21	1	21	MTC	32	21	24	0	0	10
22	1	22	MTC	40	3	5	0	0	0
23	4	23	DEFENSE	25	13	9	0	0	11
24	1	24	MTC	37	2	13	0	0	3
25	1	25	MTC	33	24	10	6	0	5
26	4	26	DEFENSE	35	14	32	0	0	16
27	2	27	ATTACK	15	5	29	0	0	12
28	4	28	DEFENSE	37	13	5	0	0	3
29	2	29	ATTACK	42	7	29	0	0	3
30	2	30	ATTACK	24	8	9	0	1	3
31	4	31	DEFENSE	53	8	7	0	0	2
32	1	32	MTC	37	4	11	0	0	11
33	2	33	ATTACK	22	0	13	0	0	11
34	4	34	DEFENSE	25	10	8	0	0	12
35	2	35	ATTACK	25	7	11	0	1	11
36	4	36	DEFENSE	31	14	18	0	0	27
37	1	37	MTC	22	14	15	2	0	4
38	4	38	DEFENSE	14	5	30	0	1	10
39	1	39	MTC	20	0	6	0	0	10
40	4	40	DEFENSE	30	3	19	0	0	8
41	1	41	MTC	25	6	27	0	0	20
42	4	42	DEFENSE	32	11	4	0	0	0
43	2	43	ATTACK	60	33	23	0	0	7
44	2	44	ATTACK	21	7	10	0	0	8
45	4	45	DEFENSE	54	19	5	0	0	1
46	1	46	MTC	58	4	6	0	0	1
47	1	47	MTC	33	0	1	0	0	0
48	2	48	ATTACK	37	12	8	0	0	3
49	4	49	DEFENSE	54	14	11	0	0	11
50	1	50	MTC	40	1	11	0	0	6
51	1	51	MTC	29	6	18	0	0	7
52	4	52	DEFENSE	36	14	19	0	0	10
53	2	53	ATTACK	30	8	5	0	0	6
54	1	54	MTC	19	6	2	0	0	0
55	4	55	DEFENSE	30	11	8	3	2	9
56	4	56	DEFENSE	31	9	7	0	0	2
			Averages	32.554	10.52	13.25	0.48214	0.39286	6.60714

they did provide some additional insight into how the task force exercised command and control over the mortar platoon and the level to which the fires of the platoon were integrated into the task forces' plans. Initial data obtained from a review of these orders is contained in Table B.5. As indicated in the table, the orders for 32 battles were actually available. For each of those battles, the following information is displayed:

- the operation type for which the order was written
- the location of the mortar platoon's mission within the order
- the mission type assigned to the platoon, the command relationship imposed upon the platoon, and the specified or interpreted deployment option
- a measure of the information contained in the order concerning firing locations for the mortar platoon
- the position of the mortar platoon leader in the TF FSO chain of succession
- an indicator variable (generated as a result of an order review) identifying whether or not the mortar platoon's prescribed mission and employment option satisfied doctrinal recommendations.

MTP Performance Data

The Mission Training Plan Performance Data logs kept at the JRTC are a fertile source of data and should serve as a strong foundation for future analyses. These logs are computer maintained databases that record observer ratings for each MTP training task and subtask for each element of the participating Task Force. The MTP set is tailored for each training battalion. Each major task is rated as "trained," "needs practice," or "untrained," while subtasks are given ratings of "go," "no-go," "not observed," or "not applicable." Other data tied to the ratings include identification of the operating system associated with the task and whether the task was conducted during the planning, preparation, or execution phase of the battle.

This database was reviewed to determine tasks that might provide insight into the performance of the mortar platoons and a sample of the available data was extracted. Information from 11 rotations was collected for 17 subtasks. The subtasks and the associated performance scores are shown in Table B.6.

In addition, the database compiles fire mission data that detail the number of missions fired by each type of indirect fire weapon system, the number of effective missions, the number of enemy KIA, and the number of rounds expended for each indirect fire system type that participated in the battle. Again, a sample of data was extracted for 12 rotations

Table B.5

NTC Orders Review

EVENT NUMBER	ORDERS AVAIL? 1=YES 0=NO	TYPE OPERATION	LOCN OF MTR MSN 1=BASIC ORDER 2=MNVR EXEC MTRX 3=FS MTRX 4=COMBO OF 1,2,3 0=NO MSN IN ORDER	MSN IN ORDER F=PRI OF FIRE T=PRI TGT B=BOTH N=NEITHER NS=NONSTD MSN X=NO MSN ASSGND	C&C IN ORDER 1=TF CONTROL 2=OPCON	DOES PLATOON MSN /LOCN DOCTRINALLY SPT TYPE OPN DIS-SECDRY AVE OF APP DA-SMK MSN, FWD PSN MTC- SPT ADVD GUARD HA-PRIORITY TO SMK 1=YES 0=NO	ORG IN ORDERS S=SECTION P=PLATOON SQ=SQUAD	FIRING POSN INFO 1=POSNS ID'D IN ORDER 2=POSNS & AZ OF FIRE IN ORDER 3=NO POSN INFO IN ORDER	MORTAR PL IN FSO CHAIN OF SUCCESSON 0=NO 1=YES BUT LAST 2=YES & FIRST 3=NO CHAIN SPECIFIED
1	1	MTC	1,2	F	1	1	S	3	3
2	1	DIS	1,2	F	1	0	P	3	1
3	1	HA	4	F	1	0	P	1	1
4	1	MTC	2	F	1	0	S	3	1
5	1	DA	2	B	1	1	P	3	1
6	0	DA							
7	0	DIS							
8	0	DA							
9	0	DIS							
10	0	CA							
11	0	DA							
12	0	DA							
13	1	DIS	3	F	1	0	S	1	0
14	1	MTC	4	F	1	1	P	1	0
15	1	DA	1,3	F	1	1	P	1	0
16	1	DIS	1,3	B	1	0	P	1	0
17	1	DA	1,3	B	1	1	P	1	0
18	1	DA	2,3	F	1	0	S	3	0
19	1	DIS	0	X	1		P	3	0
20	1	HA	1	NS	1	1	S	3	0
21	1	NA	0	X	1		P	1	0
22	0	DIS							
23	1	DA	0	X	1				
24	1	DIS	0	X	1				
25	0	HA							
26	0	NA							
27	0	DA							
28	1	HD	2,3	F	1	1	P	1	0
29	1	MTC	1,2	F	1	1	P	3	0
30	1	DA	1,2	F	1	1	P	1	0
31	1	DIS	4	F	1	1	P	1	0
32	1	MTC	2,3	NS	1	0	P	3	0
33	1	NA	1	F	1	1	P	3	0
34	1	MTC	4	F	1	1	P	3	0
35	1	DIS	2,3	F	1	0	S	1	0
36	1	DA	0	X	1	0	S	3	0
37	1	HA	3	T	1	0	P	3	3
38	1	NA	3	F	1	0	P	3	3
39	1	MTC	3	T	1	1	P	3	0
40	0	DA							
41	1	DIS	2	NS	1	0	P	1	3
42	1	DIS	0	X	1	0			
43	1	DA	1	NS	1	0	P	3	0
44	1	DA	1	NS	1	1	S	1	3
45	1	DIS	0	X	1		P	3	3
46	1	HA	1	NS	1	0	P	3	0
47	1	MTC	3	NS	1	1	P	3	0
48	1	DA	3	NS	1	1	P	0	3
49	1	DIS	2	F	1	1	P	3	3
50	1	DA	2,3	B	1	1	S	1	3
51	1	MTC	2	NS	1	1	P	0	3
52	1	DA	2	NS	1	1	P	2	3

Table B.6

JRTC MTP Performance Data

Task	Task Statement	# of Resp	Not Obs	Not App	No Go	Go
627-3	FSO makes detailed coordination with Mortar Platoon Leader	30	0	0	25	5
627-3a	Mortar Platoon Leader understands his part in the FS plan	30	0	0	18	12
627-3b	Mortar Platoon Leader informs FSO on limitations, ammo status, resupply, displacement and support required	30	0	0	23	7
627-3c	FSO coordinates mortar radio frequencies and who will monitor	30	0	0	16	14
627-3d	FSO includes mortars in target list planning and dissemination	30	0	0	17	13
627-3e	Mortar platoon provides FSE with continuous status updates	30	0	0	27	3
705-3a	Mortar Platoon Leader receives and understands commander's guidance	32	1	5	9	15
705-8	Mortar Platoon Leader receives battalion OPORD and finalizes mortar plt OPORD	32	0	2	4	24
705-8a	Indirect fire plan facilitates TF scheme of manuever	32	0	1	9	22
705-8b	Plan establishes control measures that depict platoon's scheme of maneuver	32	0	3	16	13
705-8c	Displacement plan is developed that facilitates necessary movement	32	0	1	14	17
705-8d	Plan supports the mission and the commander's intent	32	0	1	9	22
705-8e	Plan provides optimal support to units with priority of fires	32	0	4	11	17
706-9	Platoon conducts rehearsal	32	0	5	26	1
707-4i	Platoon occupies, ready to fire, within 7 minutes	32	10	5	10	7
707-5f	MET corrections are computed to nearest 1 mil	32	10	13	9	0
707-6a	Fire registration and confirm/adjust a parallel sheaf	32	16	14	0	2

and 42 battles from the database, and the results for the Blue Forces artillery and mortars are depicted in Table B.7.

FIELD DATA CARDS

Development

While the archival data sources employed measured the overall performance of the indirect fire systems, they provided little insight into the underlying causes for the observed

Table B.7

JRTC Fire MSN Data

ROTATION	BATTLE	TYPE MISSION	WEAPON SYSTEM	# OF MISSIONS	# OF EFF MISSIONS	# KIA	# OF RDS
1	1	Search & Attack	105mm HOW	66	2	2	271
	1	Search & Attack	60mm MRTR	3	0	0	16
	1	Search & Attack	81mm MRTR	9	0	0	91
	2	Air Assault	105mm HOW	75	5	6	437
	2	Air Assault	60mm MRTR	10	0	0	25
	2	Air Assault	81mm MRTR	12	0	0	75
	3	MIC Defense	105mm HOW	44	4	22	734
	3	MIC Defense	155mm HOW	12	1	0	194
	3	MIC Defense	60mm MRTR	13	3	0	138
	3	MIC Defense	81mm MRTR	12	3	4	140
	4	Deliberate Attack	105mm HOW	84	4	0	1213
	4	Deliberate Attack	155mm HOW	21	3	1	322
	4	Deliberate Attack	81mm MRTR	14	1	0	129
2	5		105mm HOW	20	1	7	274
	5		81mm MRTR	10	0	0	117
	6		105mm HOW	65	2	3	2308
	6		60mm MRTR	1	0	0	1
	6		81mm MRTR	27	0	1	506
	7		105mm HOW	45	3	62	1604
	7		155mm HOW	12	2	9	250
	7		60mm MRTR	11	2	10	175
	7		81mm MRTR	15	3	4	146
	8		105mm HOW	23	4	8	364
	8		155mm HOW	3	1	1	104
3	9		105mm HOW	16	0	0	183
	9		60mm MRTR	1	0	0	36
	9		81mm MRTR	7	0	0	38
	10		105mm HOW	36	0	13	1229
	10		60mm MRTR	3	0	0	18
	10		81mm MRTR	7	1	1	38
	11		105mm HOW	20	2	5	930
	11		155mm HOW	10	0	7	364
	11		60mm MRTR	1	0	0	8
	11		81mm MRTR	1	0	0	4
	12		105mm HOW	44	7	21	2460
	12		155mm HOW	2	0	0	152
	12		81mm MRTR	1	0	0	10
	13		105mm HOW	15	2	4	638
	13		155mm HOW	2	1	3	28
	13		81mm MRTR	4	1	2	32
4	14		105mm HOW	302	13	44	3722
	14		60mm MRTR	5	0	0	28
	14		81mm MRTR	44	4	12	410
	15		105mm HOW	55	2	20	583
	15		155mm HOW	23	0	15	280
	15		60mm MRTR	3	0	0	33
	15		81mm MRTR	12	1	18	440
	16		105mm HOW	26	3	44	742
	16		155mm HOW	4	2	37	128
	16		60mm MRTR	1	0	0	43
5	17		60mm MRTR	13	0	0	93
	18		60mm MRTR	11	0	0	95
	19		60mm MRTR	13	2	3	84
	20		60mm MRTR	16	0	0	154
6	21	Hasty Attack	105mm HOW	175	5	1	1166
	21	Hasty Attack	60mm MRTR	8	2	2	31
	21	Hasty Attack	81mm MRTR	25	3	0	243
	22	MIC Defense	105mm HOW	45	7	5	331
	22	MIC Defense	155mm HOW	5	1	0	138
	22	MIC Defense	60mm MRTR	3	0	0	6
	22	MIC Defense	81mm MRTR	10	1	0	117
	23	Deliberate Attack	105mm HOW	149	0	0	827
	23	Deliberate Attack	155mm HOW	15	0	0	102
	23	Deliberate Attack	60mm MRTR	2	0	0	8
	23	Deliberate Attack	81mm MRTR	9	0	0	142
7	24	Deliberate Attack	105mm HOW	20	3	8	552
	24	Deliberate Attack	155mm HOW	2	0	0	60

Table B.7 (continued)

JRTC Fire MSN Data

	24	Deliberate Attack	81mm MRTR	27	5	13	109
	25	MIC Defense	105mm HOW	35	3	8	1185
	25	MIC Defense	155mm HOW	3	1	0	72
	25	MIC Defense	81mm MRTR	1	0	0	14
	26	Deliberate Attack	105mm HOW	130	9	16	2776
	26	Deliberate Attack	155mm HOW	5	1	0	132
	26	Deliberate Attack	81mm MRTR	48	6	14	344
8	27	Airland Assault	105mm HOW	8	0	0	125
	27	Airland Assault	60mm MRTR	4	0	0	27
	27	Airland Assault	81mm MRTR	2	2	3	48
	28	Search & Attack	105mm HOW	15	1	0	246
	28	Search & Attack	60mm MRTR	1	0	0	20
	28	Search & Attack	81mm MRTR	5	1	0	72
	29	Co Defense	105mm HOW	24	6	2	214
	29	Co Defense	60mm MRTR	2	0	0	8
	29	Co Defense	81mm MRTR	4	0	0	25
	30	MIC Defense	105mm HOW	47	5	9	1043
	30	MIC Defense	155mm HOW	17	3	9	430
	30	MIC Defense	60mm MRTR	19	4	2	555
	30	MIC Defense	81mm MRTR	10	1	0	200
9	31	Search & Attack	105mm HOW	91	2	1	652
	31	Search & Attack	60mm MRTR	5	0	0	47
	31	Search & Attack	81mm MRTR	13	2	0	114
	32	Search & Attack	105mm HOW	45	7	10	875
	32	Search & Attack	155mm HOW	8	0	0	144
	32	Search & Attack	60mm MRTR	7	1	1	120
	32	Search & Attack	81mm MRTR	6	0	0	25
	33	MIC Defense	105mm HOW	15	4	0	325
10	34	Mvmnt to Contact	105mm HOW	103	7	16	2254
	34	Mvmnt to Contact	60mm MRTR	20	0	0	187
	34	Mvmnt to Contact	81mm MRTR	33	2	2	382
	35	Search & Attack	105mm HOW	60	9	14	2658
	35	Search & Attack	60mm MRTR	10	1	3	68
	35	Search & Attack	81mm MRTR	44	1	0	763
	36	Infiltration	105mm HOW	71	8	7	2142
	36	Infiltration	155mm HOW	17	3	6	308
	36	Infiltration	60mm MRTR	3	1	1	36
	36	Infiltration	81mm MRTR	11	0	0	129
11	37	Airland Assault	105mm HOW	100	8	12	1498
	37	Airland Assault	60mm MRTR	11	0	0	135
	37	Airland Assault	81mm MRTR	16	0	0	116
	38	MIC Defense	105mm HOW	75	4	8	1213
	38	MIC Defense	155mm HOW	21	0	10	277
	38	MIC Defense	60mm MRTR	24	0	0	416
	38	MIC Defense	81mm MRTR	20	1	0	188
	39	Infiltration	105mm HOW	16	4	20	322
	39	Infiltration	155mm HOW	5	1	6	154
	39	Infiltration	60mm MRTR	1	0	0	1
12	40	MIC Defense	105mm HOW	56	4	5	1802
	40	MIC Defense	155mm HOW	11	1	1	139
	40		60mm MRTR	7	1	3	75
	40	MIC Defense	81mm MRTR	20	2	8	182
	41	Infiltration	105mm HOW	142	5	6	1672
	41	Infiltration	155mm HOW	18	0	0	204
	41	Infiltration	60mm MRTR	6	1	0	25
	41	Infiltration	81mm MRTR	25	2	7	241
	42		105mm HOW	58	4	5	1577
	42		155mm HOW	5	1	4	82

manner of performance. Therefore, field data cards were developed to enable the Observer/Controllers (O/Cs) at each CTC to answer specific questions about the performance of the mortars. The technique of employing field data cards had been successfully employed in previous RAND studies conducted at the NTC. The cards served as a means of successfully extracting data without expending inordinate manpower or imposing an unacceptable workload on the Operations Group. In fact, in previous studies as well as the current effort, the field data cards became the primary source of analytical data.

Field Data Card Structure

Six different data cards were developed and fielded according to the scheme shown in Table B.8. A sample card appears in Fig. B.1.

Table B.8

Data Card Distribution Scheme

SET	VERSION	WPN CALIBER	CTC
A	1	4.2-in	NTC
A	2	4.2-in	CMTC
B	1	81mm	NTC
B	2	81mm	JRTC
C	1	60mm	NTC
C	2	60mm	JRTC

The card sets for both the 4.2-in mortar platoon and the 81mm mortar platoon contain a two-sided card for the mortar platoon O/C and a one-sided card for the Task Force FSO O/C. The card set for the 60mm mortar section is a two-sided card to be completed by the company O/C. Two variations of the same cards were prepared for each type mortar system with different variations fielded at different CTCs. All six versions, however, contain the same core questions with only slight modifications in the later versions. These additional questions were generated as the study effort matured and more specific issues of concern were identified. For example, the cards fielded at the CMTC asked the platoon O/C to specifically count the number of registrations conducted while the card for the Task Force FSO O/C asked him to estimate the number of missions that were fired by the supporting field artillery but were appropriate for mortars and for which a mortar platoon was available to respond. The additional questions added to subsequent versions are included in Tables B.12 to B.23. The questions on all the cards typically require a "yes-no" answer or numerical entry; however, the O/Cs were encouraged to expound on any response that they felt required amplification.

MORTAR PLATOON DATA (FROM O/C 27)

TASK FORCE Armor___ Mech___

DATE _____ MISSION MTC___ DA___ HA___

DIS___ Other _____

P Were mortars integrated into fire plan? (Y N)

P Were mortars integrated into maneuver plan? (Y N)

P Was there a specific plan to employ dismounted infantry (breach, assault, defend battle position, etc)?

P If so, were mortars given specific support assignment? (Y N)

E Were mortars fires called as integral part of artillery system (Y N) or as a separate system? (Y N)

E Were mortar fires called on artillery net or mortar platoon net? (A M)

E How many mortar missions were called but not fired? _____

Reasons _____

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Card 1

MORTAR PLATOON DATA (FROM 19)

TASK FORCE Armor___ Mech___

DATE _____ MISSION MTC___ DA___ HA___ DIS ___

Other _____

P Did platoon leader participate in TF planning?_____

P Was pn leader present at TF orders brief?___ and rehearsals?___ R

P Was platoon leader deployed by section ( ) or as platoon ( )?

P Was platoon under TF control ( ) or OPCON/attached to team ( )?

P Did platoon leader have TF fire plan and graphics?_____

P Did pn leader understand cmdrs concept? (confer w/03 and 27)_____

P Was platoon given priorities of fire ( ), priority targets ( )?

P If not, what missions were assigned?_____

P Who selected platoon fire positions (S-3 TF FSO, plt ldr, Co cmdr, Co FSO? _____

P How many positions were selected?_____

R Were positions reconned?___ , prepared?_____

R How were fire position grids located? Map ___ Hasty survey___ Survey ___

R Was there a mortar rehearsal?___ With who else?___

E Who made relocation decisions?_____

E What radio nets did FDC monitor? TF cmd___ , mortar FD___ , arty FD ___ , other_____

E What radio nets did pltn ldr monitor? TF cmd ___ , mortar FD ___ , co cmd ___ , other_____

R What was ammo status at start (rnds) HE ___ ,WP___ ,Ill ___

R How many carriers were operational at start?_____

E How many carriers killed___ or deadlined ___ during event?

Card 2 front

P Was Cl. V resupply planned to take place during event?___

E Was mortar ballistic computer up during event?_____

E Were platoon displacements up to standard?_____

E Was platoon firing preparation according to standard? _____

MORTAR FIRE LOG

Called by	Fired (Y N)	Aim pt. (grid, direct, TRP)	Target (tank APC, inf, etc.)	No. rounds (HE, WP, Ill)	Adj. (Y N)	Eff. supp. ineff.

E How many received missions not fired?

E Why? Range ___ No ammo ___ Commo ___ Unit not prepared to fire?___

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Card 2 back

NOTE: This set was fielded at the NTC for the Heavy Mortar Platoon. The questions that constitute the different sections are indicated with the letters P, R, or E.

Fig. B.1—Typical Field Data Card Set

The field cards contain four sections:

1. an initial administrative section
2. questions concerning the planning conducted for the employment of the mortar element
3. questions investigating preparatory efforts
4. questions concerning mortar performance during the execution phase of the battle.

The administrative section captures the information necessary to catalog the battle data. All unit designations were ignored and battles are identified primarily in terms of the type task force deployed and the mission type conducted. This information facilitates several different approaches to data analysis. For example, did the data reveal any significant difference in the employment of the mortars by armor-heavy task forces vice mechanized infantry units? Were mortars typically more effective in a defensive scenario than in an offensive battle? One specific difference between the cards fielded for the 4.2-in platoons at the NTC and those at the CMTC addressed the credentials of the platoon leadership. Following each rotation at the NTC, the O/Cs were debriefed and asked if the platoon leader was a graduate of the IMPOC course and if the authorized E-8 platoon sergeant was currently assigned and present. Since it was impossible for us to debrief the O/Cs at the CMTC following each density, this question was included on the card.

The second group of questions addresses the planning conducted for the employment of the mortars and each question is identified on the sample cards in Fig. B.1 by the letter "P." There should be a strong link between the quality of planning conducted and the subsequent performance of the unit, hence, several issues of concern are highlighted in this section. First, current doctrine is ambiguous as to who exercises actual command and control over the mortar platoon. Ultimate responsibility for the employment of the platoon rests with the Task Force commander, but several documents offer different alternatives as to which staff officer will manage this asset. Several questions in this group attempt to identify that staff officer, to define the level of interaction between the mortar platoon leader and the Task Force staff, and to measure the degree of operational freedom granted to the mortar platoon leader. Second, the manner in which the platoon is deployed is examined in detail. Several questions attempt to identify trends concerning the mission type assigned, the platoons' usual deployment configuration, and the typical command relationships imposed. An attempt is made to measure the training units' inclination to use the mortars as a

dismounted infantry support weapon. Again, the intent of these inquiries is to compare the trends demonstrated in the field with the variety of options presented in the doctrinal literature. Finally, several questions are designed to explore the degree to which the mortars are integrated into the plans of the Task Force. Specific questions were added to the cards fielded at the CMTC, which are intended to determine the degree to which that integration occurs. For example, does integration into the Task Force fire plan include the assignment of particular targets and are specific FOs detailed to initiate those missions? Special attention was directed toward the equipment transportation problems in the light infantry units that field 60mm mortars. In particular, O/Cs were asked to identify the mortar tube configuration adopted by the section and the manner in which issued ammunition was carried.

The third major group of questions addresses the actions conducted in preparation for the battle and each question in this group is marked in Fig. B.1 by the letter "R." One key subset of this group is intended to measure the platoons' state of logistical readiness. Of prime concern was the ammunition status at the start of the battle, as this information could then be compared with expected doctrinal consumption rates, actual counts of munitions expended, and prescribed combat and basic loads. A second key subset of questions in this group focuses on the conduct of rehearsals at both the platoon and Task Force level. Several recent publications have encouraged the use of rehearsals and have highlighted their importance as a tool for synchronizing the efforts of all operating systems assigned to or supporting the Task Force. Whether or not the mortar platoon participated in the maneuver and fire support rehearsals conducted by the Task Force would also provide some insight into how well the mortars are integrated into the overall Task Force plan. The conduct of a rehearsal at platoon level should provide some indication of the state of readiness within the platoon. A final subset of this section addresses the issue of position selection and preparation, with emphasis placed on the manner in which the firing position location was determined. Such a measure could reflect the task forces' concern for the accuracy of fire support provided.

The final series of questions characterizes the performance of the mortar platoon during the execution phase of the battle and is indicated with the letter "E." The primary subset of questions addresses the nature of the fire support provided by the mortars. These questions are designed to gather specific data concerning the number of missions fired, the type of munitions expended, the nature of the targets attacked, and the usual initiator of mortar fire missions. Moreover, this group attempts to quantify the impact of several factors that have been repeatedly cited as constraints on the utility of the mortar system, including a

relatively short range and a limited ammunition haul capability. The 4.2-in mortar data cards for the CMTC also contain several additional questions designed to determine the number of mortar-appropriate missions for which artillery assets were utilized. These data may help identify an upper bound on the missions a heavy mortar platoon might be expected to fire. A second subset of questions within this group defines the reliability of certain key systems, such as the mortar carrier and the Mortar Ballistic Computer, the failure of which might reduce the platoons' efficiency. A third subset requires the O/C to determine the ability of the platoon to conduct position occupations and displacements according to published standards. While one of the basic assumptions of this study was that crew- and platoon-level training was not a major contributing factor to the perceived ineffectiveness of the mortar system, it was still informative to identify those cases in which the performance of the observed platoon fell significantly below acceptable standards. Finally, one very important subset of questions contained in this group identifies the communication nets in which the mortar platoon is an active subscriber. One hypothesis logically argues that if the mortar platoon is accessible only through a separate communications network, then the responsiveness of that system and the ability of the platoon leadership to monitor the battle and to remain proactive is doubtful.

Initial Data from the Field Data Cards

Table B.9 indicates the number of battles for which the data cards were fielded and for which observations were received. The data collected during these battles have been translated into a series of databases. The initial, unprocessed results have been tabulated and are displayed for review according to the scheme identified in Table B.10.

Table B.9

Battle Sample Size by CTC

Type Battle	NTC (4.2-in)	CMTC (4.2-in)	NTC (81mm)	JRTC (81mm)	NTC (60mm)	JRTC (60mm)
Offensive	44	30	12	8	19	11
Defensive	20	12	10	3	20	9
Low intensity conflict	—	—	—	—	—	8
TOTAL	64	42	22	11	39	28

NOTE: The battles reported for the 60mm sections represent company activities in a battalion operation. If the reporting system was perfect, the number of 60mm battles at a CTC should be three times greater than the number of 81mm battles. From the NTC, on average, 2.2 companies were observed per battle, while 2.7 companies were observed at the JRTC per battle.

Table B.10

Organization of Tabulated Data

Table	Contents
B.11	Planning Data for 4.2-in and 81mm Mortar Platoon
B.12	Planning Data Provided by Heavy Task Force FSO O/C
B.13	Planning Data for 60mm Section
B.14	Preparation Data for 4.2-in and 81mm Mortar Platoon
B.15	Preparation Data Provided by Heavy Task Force FSO O/C
B.16	Preparation Data for 60mm Section
B.17	Execution Data for 4.2-in and 81mm Mortar Platoon
B.18	Execution Data Provided by Heavy Task Force FSO O/C
B.19	Execution Data for 60mm Section
B.20	Summary Fire Mission Data for 4.2-in and 81mm Mortars
B.21	Summary Fire Mission Data for 60mm Section
B.22	Average Munition Expenditure by Type Target (4.2-in/81mm)
B.23	Average Munition Expenditure by Type Target (60mm)

The data contained in Tables B.11–B.23 are unprocessed and represent the frequency of the responses provided by the O/Cs. In the cases where a "yes-no" answer was expected, the numbers in the tables are a count of each answer. In the case where a multiple choice question was posed, the tables list the responses to each of the options. In some select cases, answers are provided that represent the average response received instead of actual data. For example, the question that asks how many positions were selected has as many answers as there were battles surveyed. Similarly, questions addressing the ammunition status at the start of the battle and the number of carriers operational have a variety of responses. In these cases, an average response as well as a range of possible responses is provided.

There are minor discrepancies in the data as well as some missing observations that are to be expected in such an effort. It is impossible to compare, for example, the number of missions fired with the number of different target types attacked. In some cases the O/C did not know the nature of the target, or he simply failed to record the target type on the data card. For many fire missions conducted at the NTC, the O/C did not identify the individual initiating the fire mission. As a result, the database contains little information on the identity of the players who typically initiate fire missions. The determination of the effectiveness of the fire missions is another area that is missing a significant number of observations. Only a 46 percent response rate was received for this requirement, thus the utility of the data is suspect. Fortunately, the written THP includes effectiveness statistics that can be used in lieu of the requested data.

For two questions, observations concerning 60mm operations were not recorded on the attached tables. These addressed the manner in which the ammunition for the 60mm section

was transported and how resupply occurred. The unstructured responses covered a wide spectrum of possibilities and simply could not be conveniently reduced for inclusion in this table.

Table B.11

Planning Data for 4.2-in and 81mm Mortar Platoon

QUESTION		4.2-in PLATOON		81mm PLATOON	
		NTC	CMTC	NTC	JRTC
Did platoon leader participate in TF planning?	Yes	52	35	12	4
	No	12	5	10	7
Was platoon leader present at TF orders brief?	Yes	64	40	21	8
	No	0	2	1	3
Was platoon leader integrated into backbrief?	Yes	NA	8	NA	3
	No		26		8
Did platoon leader coordinate with TF FSO?	Yes	NA	42	NA	4
	No		0		7
Was platoon deployed	by section?	27	32	8	3
	by platoon?	37	9	13	8
	under TF control?	60	24	22	9
	OPCON/attached to team?	4	16	0	2
Did platoon have TF fire plan and graphics?	Yes	62	38	22	2
	No	2	4	0	9
Did platoon leader understand commander's concept?	Yes	54	41	20	8
	No	9	1	1	3
Was platoon assigned a mission of:	priority of fires?	25	15	6	3
	priority targets?	20	4	0	0
	both?	12	14	15	6
	nonstandard mission?	1	3	0	0
	none?	6	6	1	2
Who selected platoon fire positions?	TF Cdr?	0	0	0	0
	TF S-3?	0	5	0	0
	TF FSO?	4	5	2	2
	Mortar Platoon leader?	60	30	20	7
	Co Cdr/FSO/Other?	0	2	0	2
How many positions were selected?	Average	2.75	2.12	2.364	1.909
	Range	0 to 12	0 to 6	1 to 6	1 to 4
Was class V resupply planned to take place duringthe battle?	Yes	46	30	14	9
	No	18	11	7	2

Table B.12

Planning Data Provided by Heavy Task Force FSO O/C

QUESTION		4.2-in PLATOON		81mm PLATOON	
		NTC	CMTC	NTC	JRTC
Were mortars integrated into fire plan?	Yes	44	24	13	5
	No	20	15	5	4
Were specific targets assigned to mortars?	Yes	NA	23	NA	NA
	No		16		
Were observers linked to mortars to fire these targets?	Yes	NA	10	NA	NA
	No		29		
Were mortars integrated into maneuver plan?	Yes	41	16	15	3
	No	23	23	3	6
Was there a specific plan to employ dismounted infantry?	breaching action?	16	Yes-	5	0
	dismounted assault?	2	25	4	5
	defend battle position?	7		7	3
	other?	1		0	1
	none?	8		5	2
Were mortars assigned a specific mission in support of dismounted action?	Yes	42	9	15	4
	No	7	16	3	5

Table B.13

Planning Data for 60mm Section

QUESTION		60mm SECTION NTC	60mm SECTION JRTC
Did section leader participate in company planning?	Yes	18	13
	No	19	15
Was section leader present at company orders brief?	Yes	31	26
	No	7	2
Was section leader integrated into backbrief?	Yes	NA	13
	No		15
Did section leader coordinate with company FIST?	Yes	NA	13
	No		15
Was section deployed	by tube?	4	7
	by section?	35	20
	under Company control?	36	20
	OPCON/attchd to Plt?	1	8
Did section have company fire plan and graphics?	Yes	17	14
	No	22	14
Did section leader understand commander's concept?	Yes	34	22
	No	5	6
Was section assigned a mission of:	priority of fires?	9	8
	priority targets?	5	1
	both?	7	10
	nonstandard mission?	6	7
	none?	12	1
Who selected section fire positions?	Company Cdr?	14	8
	Company FIST?	1	1
	Section leader?	19	15
	Other?	4	4
How many positions were selected?	Average	1.33	1.6
	Range	0 to 3	0 to 7
Was class V resupply planned to take place during the battle?	Yes	10	13
	No	27	14
Were mortars integrated into fire plan?	Yes	24	19
	No	12	9
Were mortars integrated into maneuver plan?	Yes	28	15
	No	7	13

Table B.14

Preparation Data for 4.2-in and 81mm Mortar Platoon

QUESTION			4.2-in PLATOON		81mm PLATOON	
			NTC	CMTC	NTC	JRTC
Was platoon leader present at Task Force rehearsal?	Yes		54	16	20	7
	Nb		8	25	2	4
Were any positions reconned?	Yes		20	11	8	6
	Nb		44	31	14	5
Were any positions prepared?	Yes		7	1	2	2
	Nb		56	41	20	9
How were firing position grids determined?	Map spot		45	41	13	10
	Hasty Survey		15	1	0	0
	Formal survey (PADS)		4	0	9	1
Was there a mortar rehearsal?	Yes		29	4	5	2
	Nb		35	38	17	9
Did anyone outside the mortar platoon participate?	FIST		3	No Data	0	0
	FSO		1		0	0
	Scouts		0		0	1
Did the mortar platoon conduct a communications rehearsal?	Yes		NA	NA	NA	2
	Nb					9
What was ammunition status at the start of the battle?	HE	Average	427.7	203.4	402.1	302.8
		Max	1551	600	980	463
	WP	Average	194.9	88.8	122.1	81.09
		Max	574	266	351	200
	ILL	Average	55.27	38.3	80.36	57.82
		Max	205	150	242	136
How many carriers were operational at the start of the battle?	Average		5.203	4.0952	6	5.545
	Range		3 to 6	2 to 6	4 to 7	3 to 8

Table B.15

Preparation Data Provided by Heavy Task Force FSO O/C

QUESTION		4.2-in PLATOON		81mm PLATOON	
		NTC	CMTC	NTC	JRTC
Was there a Fire Support rehearsal?	Yes	NA	31	NA	NA
	Nb		8		
Did the mortars participate?	Yes	NA	7	NA	NA
	Nb		24		

Table B.16

Preparation Data for 60mm Section

QUESTION			60mm SECTION	
			NTC	JRTC
Was section leader present at company rehearsal?	Yes		7	13
	Nb		25	14
Were any positions reconned?	Yes		14	16
	Nb		25	12
Were any positions prepared?	Yes		5	7
	Nb		34	21
How were firing position grids determined?	Map spot		19	15
	Hasty Survey		3	7
	Direct Lay		8	4
	Other		4	0
Was there a mortar rehearsal?	Yes		1	7
	Nb		37	20
What was ammunition status at the start of the battle?	HE	Average	98.9	90.9
		Max	363	334
	WP	Average	27.3	22.9
		Max	150	189
	ILL	Average	25.8	12.1
		Max	80	46
What was tube configuration?	M7 with FDC		11	17
	M8 with FDC		14	5
	M8 only		5	3
	Both M7 & M8 with FDC		7	2

Table B.17

Execution Data for 4.2-in and 81mm Mortar Platoon

QUESTION		4.2-in PLATOON NTC	4.2-in PLATOON CMTC	81mm PLATOON NTC	81mm PLATOON JRTC
Who made relocation decisions?	TF Cdr	0	0	0	0
	TF S-3	0	0	0	0
	TF FSO	0	0	0	1
	Mortar Platoon Leader	53	41	16	5
	Co Cdr/FIST/Other	2	1	0	1
	None made	6	0	4	3
Did platoon displace by	Squad?	NA	NA	NA	2
	Section?	NA	NA	NA	3
	Platoon?	NA	NA	NA	4
What radio nets did the FDC monitor?	Bn Cmd & Mortar FD	64	28	20	9
	Mortar FD Only	0	T/P/F-4	0	1
	Mortar & FA FD	0	FD/PL - 2 TF/PL - 8	0	1
What radio nets did the platoon leader monitor?	Bn Cmd & Mortar FD	61	34	19	8
	Co Cmd & Mortar FD	3	TF/PL -	1	1
	Mortar & FA FD	0	8	0	1
	Bn Cmd & Co Cmd	0	-	1	0
	Bn Cmd Only	0	- -	0	1
How many carriers were lost during the battle?	Killed Average	2.593	0.95	1.13	0.54
	Range	0 to 6	0 to 4	0 to 5	0 to 4
	Deadlined Average	0.542	0.405	0.04	0
	Range	0 to 3	0 to 2	0 to 1	0
Was mortar ballistic computer up during the event?	Yes	64	42	22	10
	No	0	0	0	1
Were platoon displacements up to standard?	Yes	28	33	19	4
	No	27	7	0	6
Was platoon firing preparation according to standard?	Yes	38	36	19	6
	No	23	4	0	3
Did class V resupply occur?	Yes	NA	NA	8	6
	No	NA	NA	9	5

Table B.18

Execution Data Provided by Heavy Task Force FSO O/C

QUESTION		4.2-in PLATOON NTC	4.2-in PLATOON CMTC	81mm PLATOON NTC	81mm PLATOON JRTC
Were mortar fires called as an integral part of artillery system or as a separate system?	Artillery system	5	17	7	2
	Separate system	46	18	12	8
On which net were mortar fires called?	Artillery net	0	3	0	2
	Mortar net	52	36	19	8
On average, how many artillery missions were fired?		NA	23.9	NA	NA
On average, how many artillery missions were fired on mortar-suitable targets?		NA	4.76	NA	NA

Table B.19

Execution Data for 60mm Section

QUESTION		60mm SECTION	
		NTC	JRTC
Who made relocation decisions?	Section Leader	9	4
	Company Cdr	9	8
	Company FIST	0	0
	Platoon Leader	0	1
	Other	0	1
	None made	15	12
What radio net did the section leader monitor?	Mortar Net	7	8
	Company Cmd Net	30	16
	FA FD net	1	4
	No radio	1	0
Were section displacements up to standard?	Yes	17	6
	No	10	14
Was section firing preparation according to standard?	Yes	17	12
	No	10	12

Table B.20

Summary Fire Mission Data for 4.2-in and 81mm Mortars

QUESTION		4.2-in PLATOON		81mm PLATOON	
		NTC	CMTC	NTC	JRTC
Total number of missions called		354	219	105	175
Total number of missions fired		305	141	103	160
Number of fire missions initiated by key players	TF Cdr	3	1	0	8
	TF S-3	3	0	0	3
	TF FSO	85	13	25	10
	Company FIST	162	122	3	95
	Mortar Platoon Leader	24	2	0	2
	Other	17	5	0	24
Number of fire missions by type target	Dismounted Infantry	96	38	77	75
	Tanks	20	11	0	3
	BMP/BRDM	75	61	4	3
	Obstacle	9	1	0	0
	Unknown vehicles	26	0	0	4
	Enemy OP	18	0	0	8
	Mix of veh & Infantry	3	0	0	2
	AT5	15	0	0	0
	Smoke mission	14	16	7	27
	FPF	6	0	0	3
	Enemy bunker	2	0	0	0
	Prep	0	7	0	1
	Illum	10	8	6	8
	Other	5	1	2	27
Type Aiming Point	Grid	241	140	68	159
	Direct Lay	2	0	0	1
	Target Reference Point	38	1	27	0
Number of adjust fire missions		5	11	0	60
Reasons missions not fired	Unit out of range	41	13	0	7
	Unit out of ammo	3	10	1	1
	Commo Problems	0	2	0	1
	Unit not ready to fire	1	0	0	3
	Other	4	53	1	3
Number of registrations		1	0	0	0

Table B.21

Summary Fire Mission Data for 60mm Section

QUESTION		60mm SECTION	
		NTC	JRTC
Total number of missions called		77	110
Total number of missions fired		67	74
Number of fire missions initiated by key players	TF Cdr	0	0
	TF S-3	0	0
	TF FSO	0	2
	Company FIST	9	73
	Section Leader	2	7
	Company Cdr/Other	0	12
Number of fire missions by type target	Dismounted Infantry	32	39
	Tanks	8	1
	BMP/BRDM	6	0
	Obstacle	0	0
	Unknown vehicles	0	0
	Enemy OP	0	0
	Mix of veh & infantry	0	1
	AT5	0	0
	Smoke mission	5	1
	FPF	1	3
	Enemy bunker	5	0
	Prep	0	0
	Illum	3	5
	Other	4	13
Type Aiming Point	Grid	55	60
	Direct Lay	9	11
	Target Reference Point	2	1
Number of adjust fire missions		5	30
Reasons missions not fired	Unit out of range	6	1
	Unit out of ammo	1	0
	Commo Problems	0	3
	Unit not ready to fire	1	0
	Other	2	32
Number of registrations		1	2

Table B.22

Average Munition Expenditure by Target (4.2-in/81mm)

TYPE TARGET	NTC 4.2-in Platoon			CMTC 4.2-in Platoon			NTC 81mm Platoon			JRTC 81mm Platoon		
	HE	WP	ILL	HE	WP	ILL	HE	WP	ILL	HE	WP	ILL
Dismounted Infantry	33.4	2.6	0	17.4	0.9	0	32.2	4.1	0	10.3	0.2	0
Tanks	32	5.9	0	30	5.5	0	0	0	0	23	13.3	0
BMP/BRDM	41.1	3.7	0	25	0.8	0	89	2.5	0	9.3	0	0
Obstacles	12.5	36.8	0	0	31	0	0	0	0	0	0	0
Unknown vehicles	21.4	13.8	0	0	0	0	0	0	0	52.5	15.3	0
Enemy OPs	19.5	6.7	0	0	0	0	0	0	0	5.3	2	0
Enemy Bunker	30	0	0	0	0	0	0	0	0	0	0	0
Mix of Infantry & vehicles	34	15	0	0	0	0	0	0	0	6.5	4	0
AT5	27	5.2	0	0	0	0	0	0	0	0	0	0
Smoke mission	2.1	60.6	0	0	28.7	0	0	71.1	0	0.2	7.7	0
Illumination	2.6	5.1	7.1	0	0	9.5	0	0	22.3	0.7	0	1
FPF	180.8	0	0	0	0	0	0	0	0	3.7	1	0
Preparation	0	0	0	18.3	8.3	0	0	0	0	12	0	0

Table B.23

Average Munition Expenditure by Type Target (60mm)

TYPE TARGET	NTC 60mm Section			JRTC 60mm Section		
	HE	WP	ILL	HE	WP	ILL
Dismounted Infantry	8.9	1.1	0	6.2	0.5	0
Tanks	48.1	4	1.3	10	0	0
BMP/BRDM	12.5	0.7	0	0	0	0
Obstacles	0	0	0	0	0	0
Unknown vehicles	0	0	0	0	0	0
Enemy OPs	0	0	0	0	0	0
Enemy Bunker	10	0	0	0	0	0
Mix of Infantry & vehicles	0	0	0	4	2	0
AT5	0	0	0	0	0	0
Smoke mission	0	16.6	0	0	2	0
Illumination	0	0	10.1	0	0	2.6
FPF	20	0	0	5.3	0	0
Preparation	0	0	0	0	0	0

Appendix C
ON THE EXCLUSION OF LIVE-FIRE DATA FROM THE NTC

MOTIVATION

Our efforts to analyze the employment of mortars have been based on data gathered as a result of the dry-fire, force-on-force exercises conducted at each of the CTCs. The decision to exclude the data generated by the live-fire exercises conducted at the National Training Center (NTC) was based on three considerations:

a. The NTC is the only CTC to incorporate a live-fire exercise into a unit's rotation or training density. This raised the concern that conclusions determined based on the data generated at the live-fire exercise might not be generalizable across CTCs.

b. Initial investigation confirmed a shortage of mortar ammunition in the Army supply system; as a result, a platoon might participate in a rotation without a complete basic or even combat load of ammunition. This may introduce an unmeasurable bias in the data as units attempt to husband the ammunition for *more critical* phases of the battle or simply try to ration the ammunition so that some rounds are available throughout the entire live fire exercise. This is significantly different from the force-on-force exercises wherein the limitation on ammunition availability is the training unit's ability to conduct the appropriate requisitioning process. While an ammunition constraint may become the norm in actual combat, it was felt that it might degrade the utility of data generated during the live fire exercise.

c. Current Army safety regulations preclude the peacetime firing of mortar ammunition over the heads of soldiers. In the live-fire exercise, therefore, units must carefully select positions for the mortar platoon that allow them to fire while satisfying this constraint. The impact of this requirement on the performance of the platoon cannot be directly measured and may skew the resulting data, particularly in light of the fact that this positioning constraint is not necessary or enforced in the force-on-force exercises.

Two independent circumstances, however, motivated a review of the live-fire data generated by the NTC. First, several of the O/Cs argued that the live-fire exercise would

provide some interesting insights into the performance of the mortar platoons. Second, it became obvious through an analysis of the data collected during force-on-force exercises and through discussions with the O/Cs that the mortar platoons were not being fully penalized for a lack of accuracy in the dry-fire battles. One resultant argument is that the live-fire exercises might provide a better measure of the mortar platoons' ability to provide accurate fires.

Three unit rotations were selected for review. Each rotation involves two Task Forces and each Task Force participates in one offensive and one two-phase defensive mission during the live-fire phase. Thus a sample of 12 battles was identified for review. A synopsis of those battles as well as a critique of the performance of the organic mortar platoon and attached FIST teams and FSO is found in the Fire Support Operating System subsection of the Task Force specific enclosure to the unit Take Home Package.

This proved to be a very useful and educational experience. The review confirmed that the decision not to explicitly employ unit performance data generated during the live-fire exercise was valid.

UTILITY OF LIVE-FIRE DATA

Throughout the THPs, evidence is found that confirms the decision to exclude live-fire data. The restriction on overhead fires and the constraint on available ammunition appeared to have an impact on platoon performance. However, the need to satisfy standard range safety requirements also appears to significantly influence the mortar platoons' ability to provide indirect fire support.

Ammunition Constraint

The NTC Rules Of Engagement clearly state that the "CSR for Live Fire is that allocation of rounds for the Task Force. The actual ammo draw from the NTC ASP is the only ammo the unit is credited with." Members of the NTC Operations Group indicated that the amount of ammunition available cannot support resupplying each participating platoon with a complete basic load for each battle. In one battle, the platoon fired only 113 rounds before it ran out of ammunition. While the author of the THP fails to identify whether this was the result of a unit failure or an NTC-imposed ammunition constraint, he does report that this is a battle in which the ingredients for success are clearly present. The Task Force FSO had taken aggressive action to integrate the mortar platoon into the fire plan. Each FIST had a copy of that plan and knew which targets were designated mortar targets; the mortar FDC also had a copy of the fire plan and had predesignated targets for each of the

platoon sections. Unfortunately, the platoon was only able to fire 8 missions before it had consumed all available ammo. Surprisingly, this is the largest number of rounds fired by any one platoon in the 12 battles reviewed, yet it represents a level of consumption that is significantly lower than the average number of rounds fired by a mortar platoon during a dry-fire, force-on-force mission. A comparison of ammunition consumption rates shown in Table C.1 indicates that the usage factor for indirect fire support systems varies significantly between dry- and live-fire exercises. While it is impossible to determine how much of this results from actions of the training unit and how much is caused by real world supply shortages, it certainly argues for limited comparison of the data.

Table C.1

Rounds Per Battle

	Dry Fire	Live Fire
Field Artillery	2520	480
Mortar Platoon	216	42

NOTE: The field artillery/mortar ratio is about the same dry fire and live fire.

It is interesting to note that ammunition shortage may have some impact on force-on-force operations. The Fire Support Trainers (Werewolves) argue that:

> Mortar platoons have no confidence in the resupply system, often fire fewer rounds per target than called for, and therefore lack the volume of fire needed to have effects on the target. (They lack confidence for good reason. The mortars have no dedicated resupply and must compete with TOWs, tanks, and infantry for haul capacity.) [14]

Whatever the reason, the significant observation is that mortar platoons in the dry-fire scenarios repeatedly fail to consume even that ammunition that composes the simulated on-hand combat load. The desire to constantly husband ammo may find its genesis in the live-fire exercises conducted by the platoon both at the NTC and at the home-station.

Overhead Fires

The restriction on overhead fires is a peacetime safety requirement based on the failure of mortar ammunition to meet certain safety specifications. Throughout the battles reviewed, this restriction is apparent as mortar platoons continuously jockey for positions on the flanks of the maneuver Task Force. One report examines the efforts of a mortar platoon leader to position his platoon so that he could provide effective support, and to request permission to move out of sector to a position on the flank of the Task Force. The request

was denied and the platoon was unable to respond to the first call for fire because of the overhead fires restriction. In another battle, the platoon is in position and about to respond to a call for fire when one of the maneuver units enters the platoon's range fan and, as a result, the fire mission is cancelled. Due to this restriction, Task Force planners may have to select mortar positions that contradict doctrinal employment. Information must now be generated, which the unit may not be prepared to create or distribute. For example, not only must the mortar platoon now monitor the trace of the FLOT, but it must also monitor the position of every unit that might be positioned within its range fan. However, this influence on the performance of the platoon may be impossible to quantify and the resulting data difficult to interpret.

Safety Restrictions

Based on discussions with O/Cs, the only factor affecting the accuracy of mortar fires in the force-on-force scenarios is the ability of the observer to accurately locate the target. One O/C team penalizes a platoon if the reported position location is sufficiently in error but usually coaches that unit to correct the error. A second team disregards any location error during the conduct of simulated fire missions and only mentions the error during the AAR. Other ingredients for accurate fire, e.g., boresighting weapons, declinating aiming circles, registering mortars, or firing correct data, may or may not be checked depending on the initiative of the O/C and time available; but these factors have no impact on the accuracy and effectiveness of the mission fired. Simply speaking, a round is assumed to land at whichever grid the observer identifies as the target location. If that location is accurate, the mission may be effective even if the platoon does not register, does not boresight their mortars, and does not know where they are located. Consequently, one could argue that even the current limited effectiveness of the mortars in the dry fire missions is clearly an exaggeration of their capability. On the other hand, in the live-fire exercises, units must grapple with and often fail to satisfy the requirements for accurate and safe fires.

The results illustrated in Table C.2 must be very carefully interpreted. First, and most important, these results argue that the accuracy of the mortar system may not be as robust as currently depicted in the force-on-force exercises. Second, they are indicative of some internal training problems. Third, the data serves to further discourage the use of live-fire results, for the following reasons:

Table C.2

Mortar Firing Errors

Possible Source of Error	Battle in which error was observed and recorded											
	1	2	3	4	5	6	7	8	9	10	11	12
Mortars not registered		X				X	X			X		X
Aiming circle not properly declinated			X		X							
Wrong charge fired												X
Wrong fuze setting fired	X											
Incorrect data fired			X									
Boresighting error				X					X			
Incorrect "lay" procedure	X		X								X	

1. After almost all of the firing accuracy errors were identified, the THP indicates that remedial training and/or check fires were imposed that precluded the platoon from providing support for some remaining portion of the battle. However, the length of downtimes are not explicitly identified and the impact of downtime on expected support cannot be measured.
2. There is no defined format for the THP. Consequently, omission of any comments concerning a mortar registration, for example, cannot be construed as evidence that the event did or did not occur. The O/C may simply have ignored the issue because he felt another topic was more worthy of discussion. One issue, which is only sporadically discussed, is the manner in which the location of the firing position is identified. The O/Cs tend to report if PADs was employed, but generally do not report any other means of position location or the accuracy of the final location determination. (Note: NTC ROE do not require mortar positions to be surveyed during live fire exercises). In fact, it cannot be determined if the THPs represent worst-case reporting or possibly just the "tip of the iceberg."
3. Some of these errors may come to the attention of the O/C only when they are significantly large or clear safety violations. Depending on how the determination of mission accuracy is made (an issue which must be explored further), small errors which might impact the lethality of the weapon system may go unnoticed.

In conclusion, the decision to concentrate on force-on-force generated data appears valid. There are several significant constraints imposed on the platoon during the live-fire exercise for that the impact cannot be accurately measured. However, certain trends become

apparent during these live-fire missions that support hypotheses developed during a review of the force-on-force generated data. Those findings are discussed in App. B.

Appendix D
INSIGHTS FROM LIVE-FIRE THP REVIEW

OPTIMAL MORTAR EMPLOYMENT

The THPs provide very clear insight into the fragile nature of the fire support system. Hardly a battle critique can be read that does not contain some discussion of a fire support system component failure that either dramatically diminishes the caliber of support provided or simply paralyzes the system. Certainly, each of the accuracy errors identified in App. C represents failures that prevent the mortar platoon from providing responsive, accurate fires. Unfortunately, those errors represent only a small portion of the list of mistakes that can cripple the system. The following scenarios are taken from Take Home Packages.

> . . . the rehearsal was hampered by the absence of the Task Force FSO who, as directed by the TF commander, was acting as a direct fire target for the TF in their rehearsal. Thus the rehearsal was disjointed and many problems which arose were never detected and corrected.
>
> . . . two FISTs were kicked out of their dug-in fighting positions by their company commanders to make room for M1s. Only one of the two FISTs was able to find a good hull-down position prior to the battle and both were still exposed to artillery and flanking fires.
>
> As the TF crossed the LD, the TF FSE's M577 broke down. Team Panther's FSV was lost and arrived late to its overwatch position and later broke down as well. One of the dismounted company FSOs had his PRC77 hand mike taken away by the company commander and was thus rendered ineffective. One additional FSV and crew was killed and the other FSV was killed as it ascended the escarpment.
>
> As the enemy came within the TF's sector of responsibility, the fire support section was unable to engage the moving enemy in a timely manner. Good grids were being sent, but because no trigger points had been established, a product of the target area survey, fires arrived after the enemy crossed the target grid.
>
> . . . the mortar platoon received a mission for illum. The response from the gun squad that was supposed to provide the illum was extremely slow because their aiming stakes had fallen down.
>
> Because the TF FSO was positioned in a Bradley, he did not know that the TF was advancing towards the intermediate objective and that the artillery was not firing as they had reported. Additionally, the FSO could not observe that the enemy was not in the first planned target area but had concentrated in the second target area. As a result, the TF FSO tried to focus the artillery on firing according to plan rather than where the enemy was.

Even when everything appears to be properly rehearsed and synchronized, the fire support system is clearly analogous to a chain that is only as strong as its weakest link. Imagine the frustration of the mortar platoon leader who experiences the following:

> The mortar platoon received PADs to survey their position and also to set up a declination station in order to declinate their aiming circles. The platoon also prepared individual fighting positions. Range cards and sectors of fire were assigned for direct fire weapons. The mortar platoon leader and platoon sergeant requested small arms ammo. The FDC precomputed firing data for their assigned targets and the gun squads prepared ammo for the preplanned targets. The platoon conducted battle drill rehearsals.
>
> During the day defense, the mortar platoon received a call for fire which they could not execute because all calls for fire had to be cleared by the TF FSO, *but nobody had radio commo with him.*

The THPs do, however, contain more than examples of random applications of Murphy's Law to the fire support system. From a review of the sample of battles, several ingredients for the optimal employment of the mortar platoon can be identified. These ingredients include:

1. Developing the communications links to allow fire missions to be expeditiously requested and executed.
2. Insuring that measures are taken to enhance the accuracy of target location.
3. Insuring that the mortar platoon has satisfied all internal requirements for accurate fire.
4. Insuring that the mortar platoon understands the volume of fire required to defeat particular targets.

However, each of these ingredients can be considered "second-order" challenges in comparison to the one requirement that clearly develops throughout the THP critiques as the key and essential element for optimal mortar employment. That ingredient is the preparation of a simple fire support plan that captures the commander's intent, exploits the capabilities of the mortars, and which is distributed to and understood by both the mortar platoon and the company FSOs who will implement it.

The requirement for a plan that incorporates the mortars is an obvious, but often overlooked, necessity. If the fires of the platoon are not explicitly planned and published, then the platoon will sit idle. No amount of aggressive action on the part of the mortar platoon leader will overcome a failure to incorporate the mortars into the fire plan. Even a

platoon that is registered and occupying a surveyed location will have no impact on the battle if no fire missions are initiated. Certainly, this is not a novel conclusion. The Fire Support Trainers [14] argue that "maneuver commanders and FSOs often neglect their mortars" and that the "mortars do not receive target lists, OPORDs, ACAs, FPFs, or priority targets." In a very perceptive article entitled "Top Down Fire Planning," [19] Lieutenant Colonel Robert Sander proposes the following,

> Fire planning for mortars is critical to the task force. A simple plan works best. Consider giving the mortar platoon a specific mission during each phase of the operation. The platoon could be dedicated to support a specific company or team or be designated as the primary indirect fire agency for specific targets in the task force plan. In any case, the platoon's mission must be realistic and clearly understood both by the platoon and the observers who will be calling for mortar fires.

One of two platoon types are repeatedly described in the THPs: (1) the platoon that was ignored during the planning process and sits idle during the actual operation and (2) the platoon that is integrated into the fire plan and rehearsal, and is capable of providing effective, responsive fire support. (This second platoon is only *capable* of providing effective support. How well it achieves that potential is, in fact, determined by how it responds to the *second-order* challenges.) Consider the following extracts from the battle critiques reviewed:

> Battle #1: "The fire support execution matrix was vague and lacked specificity in regards to the role the mortars had in the plan. A fire support rehearsal was conducted prior to the start of the battle; however, the mortars did not participate, nor did most FISTs. The mortar platoon did not fire any missions throughout the entire offensive mission. They also did not receive any calls for fire; however, the mortar platoon leader was aggressive in telling the TF FSO and commander that he was in position and ready to fire."

> Battle #2: "While the mortars were integrated their target responsibilities were vague. . . . Mortars were not integrated into the rehearsals nor was the TF ALO. . . . Since mortars were not incorporated into the rehearsal, no missions were sent by the FIST."

> Battle #3: "Mortars were left out of the plan as well. . . . There was no defensive fire plan for the mortars. . . . The platoon was unable to execute any of the four missions called."

> Battle #4: "The reason why the platoon was able to fire all the missions was because the mortars were implemented into the fire plan and the forward observers knew what targets were mortar targets and what targets were artillery targets. The mortar FDCs also came up with a plan that would distinguish what missions each section would fire. The response to the calls for fire were very quick. Of the nine missions fired three were effective, four were suppressive and two were ineffective."

If one subscribes to the argument that a simple, yet comprehensive, well distributed plan is the key to mortar utilization, then the next concern must be identifying a mechanism which will insure that this plan is routinely developed. One suggestion calls for the development of a standard Task Force Fire Support Matrix that requires the commander to specifically address the employment considerations of the mortar platoon. Such a matrix could be derived from the Task Force Synchronization matrix proposed by Major Long in his MMAS thesis entitled "Synchronization of Combat Power at the Task Force Level; Defining a Planning Methodology." This matrix would identify more specific, suitable missions for the platoon and the command relationships necessary to execute those missions. Moreover, that matrix includes mortars under the Fire Support BOS and suggests that the FSO should have primary responsibility for the development of the mortar plan. No matter what mechanism is adopted, the plan must accomplish the following:

1. define a specific, suitable mission for the mortar platoon optimizing its contribution at the decisive point in the battle
2. identify the observer who is to initiate the mortar fires and the link to be used to contact the platoon
3. identify the manner in which the plan itself will be rehearsed.

Other Elements of Success

As mentioned earlier, there are other second- and possibly third-order elements of success. These concerns will assume an influential role once units begin planning for the appropriate employment of the platoon. Many of these elements are already obvious in the THPs and deserve additional comment.

Communications links. The need for efficient communications links is a problem that is endemic to the entire fire support operating system and has implications far beyond our current concern. However, the inability to communicate can paralyze the most effective plan.

The idea of an automated fire support system has been one of the guiding principles of the Field Artillery community for many years. The currently fielded system envisions a computer-based command and control system, with all message traffic being transmitted digitally. One component of this system, the FIST DMD, is of special interest to the employment of mortars, for it is this device which can automate the flow of mission requests from the FO to the mortar platoon. Using this device, the FIST can now review all mission requests and redirect them to the appropriate fire support asset, establish a direct link

between the observer and a particular fire support asset, or allow the observer to select the fire support asset and have the FIST DMD relay the observer's call for fire to the appropriate net. The Mortar Ballistic Computer, currently found in each mortar platoon FDC, is capable of accepting these digital messages thereby allowing the mortar platoon to be an active player in the automated fire support system.

Experience at the NTC, however, indicates that digital traffic is often abandoned and the majority of calls for fire are initiated as voice requests. Multiple observers operate on one net and quickly overwhelm the frequency. The FIST DMD, although fielded to the player units, is not exploited but sits idle throughout the rotation. Appropriate codes are not exchanged between the mortar platoon and the supporting artillery unit so that digital traffic can be transmitted to the MBC at the mortar platoon FDC. The TF FSE is undermanned when the TF FSO accompanies the maneuver commander and the FSE tends to become a relay station rather than a control station that is clearing fires and tracking the battle. Frequently, no one is keeping track of the missions in the TACFIRE cue and they tend to build up and are not cancelled when no longer needed. The artillery is then engaging targets long after the enemy has passed.

Contrary to the emphasis of current doctrine, the THPs encourage the use of voice radio nets. Consider the following extracts:

> . . . a report must be submitted by voice so that everyone can hear it. When reports are sent digitally, only one addresser and the addressee know what was reported. Therefore, the people who need the report the most, TF FSOs and FISTs will not benefit from the report.
>
> Silence is not consent. While this conflicts with FM 6-20-40, the TF FSO must know and approve all missions going into the TF sector including from his own FISTs and FSE. This is accomplished by having all missions cleared on the internal fire support net (mortar net 1) prior to the missions being sent. This allows the TF FSO and each of the other FISTs to ensure that the mission is safe and not wasting assets. Since no one can hear digital, all mission requests must be made voice. In this manner we avoid fratricides.

While this is an area that warrants additional analysis in itself, the implications for the mortar platoon are significant. If all observers operate on one net so that the FSO can clear their fires, then requests for mortar fires will have to compete among all other requests and there will be an obvious degradation of the system's responsiveness. If the TF FSOs are encouraged to assume control of one mortar net, as the excerpt above suggests, then the mortars lose an asset that can be used as a quick fire channel.

Ammunition expenditure. One issue that is seldom mentioned in the THPs for the live-fire exercises is the lethality of the mortars, or their ability to kill the target which they have engaged. This may be a function of the ammo limitation and the realization that firing the appropriate amount of ammunition at a given target simply might not be possible. However, for the 12 battles reviewed, the participating mortar platoons fired an average of 12.4 HE rounds per fire mission. This method of engagement almost insures the ineffectiveness of the platoon. The need for a clearly published and easily accessed munitions effectiveness table that suggests the appropriate amount of ammunition required to destroy, neutralize, or suppress an array of target types remains critical.

It is particularly interesting to note that several sources have expressed a concern with the inability of the platoon to haul sufficient ammunition. That concern appears trivial particularly in light of the consumption rates demonstrated in both the live- and dry-fire exercises. However, this may surface as a third-order concern especially once units begin to plan properly for the employment of the mortars and the mortar platoons are able to execute missions with accuracy and lethality. Then they may begin to consume the limited ammunition they are currently able to haul before they have executed all assigned missions.

Accuracy of fires. The last ingredient is the requirement for accuracy. Similar to the issue of radio communications links, this is a problem that affects the entire fire support community and is, as we have discussed earlier, the driving factor in the determination of effective missions at the NTC. The live-fire THP review highlighted the difficulty that units experience as they attempt to engage targets with indirect fire. The solution, which is repeatedly suggested, is the target area survey. Conducted primarily in the defensive scenario, the method requires the FSO to have each artillery target, TRP, and trigger point physically marked in some conspicuous manner. Each FIST then uses the equipment in the FIST-V to sight in on each trigger point and record orienting data. The grid for each target should be identified and submitted to the appropriate FDC for the determination of firing data. During the battle, the FISTs lay on their first trigger point and execute the target as the enemy passes the trigger point. Finally, FIST then shifts to the next trigger point based on prerecorded orienting data.

In the battle critiques reviewed, there are six defensive battles. In three of those engagements, a target area survey was not conducted. Typical comments for those battles include:

> . . . all targets were fired late and the artillery was never able to recover.

> . . . good grids were being sent, but because no trigger points had been established, a product of the target area survey, fires arrived after the enemy crossed the target.
>
> . . . targets were called late or not at all. Those targets which were fired fell behind the advancing enemy.
>
> . . . target engagement was faulty due to the inability of the FISTs to accurately locate the enemy on the map.

Conversely, those units that conducted the target area survey met with greater success including one whose critique reads as follows,

> The day battle was plagued by poor weather conditions and reduced visibility. These conditions worsened considerably by the night battle. The fire support section conducted a good target area survey and the FISTs were able to work through the adverse weather and were able to engage the enemy effectively.

CONCLUSIONS

First, optimal employment of the mortars is clearly a function of the plan developed. It may require some doctrinal "fixes" to ensure that units plan for appropriate use of the mortars. Commo links must be identified that allow for rapid transmission of fire requests. Attachment of the mortars to maneuver units may be the most efficient mode. Training both in IMPOC and PCC may have to be adjusted to address these issues.

Second, once deployed, mortar platoons must become concerned with accuracy and lethality. Platoons should expect to register and conduct hasty survey. Adjust fire missions should be the norm. Tables should be available in each FDC to determine the appropriate number of rounds to expend on a given target. The NTC and other CTCs may have to adjust their current operating procedures to more appropriately reward the suppressive effects of mortar fire.

Third, some equipment "fixes" may become necessary as the mortars are employed more. A dedicated HEMMT for each platoon would drastically improve ammo haul capability. Adjustment of carrying racks may be necessary to allow the platoon to carry more WP rounds.

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